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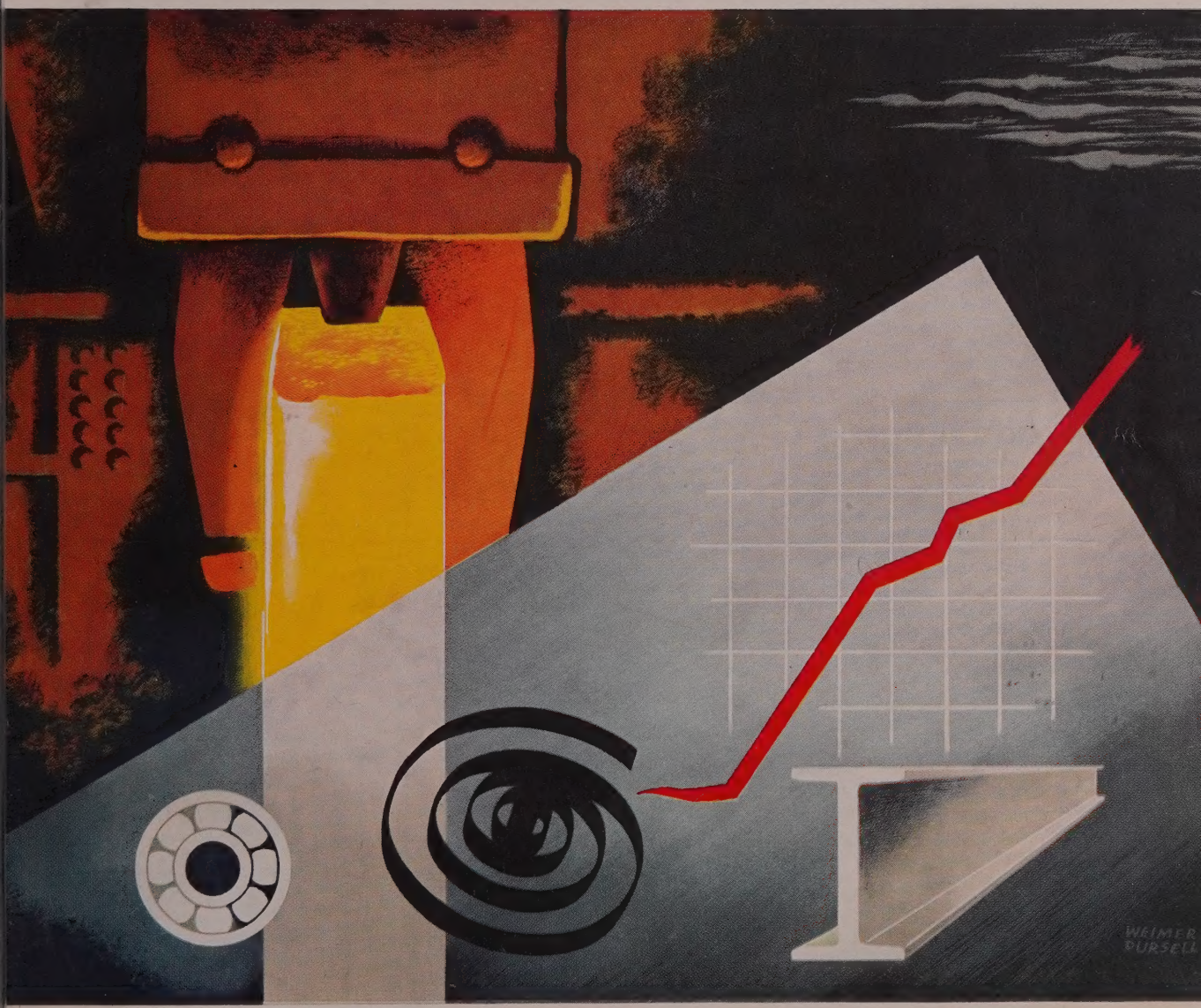

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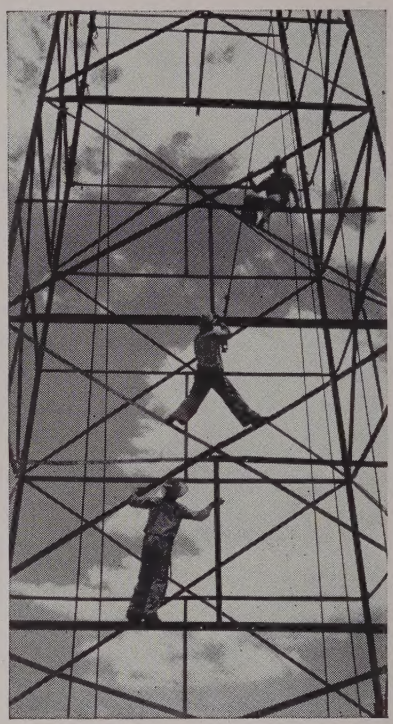

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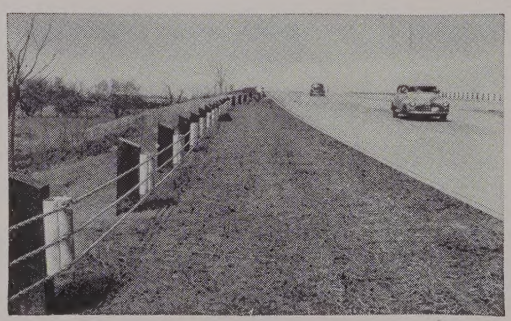

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THE ILLINOIS TECHNOGRAPH

volume 68 **number 8**

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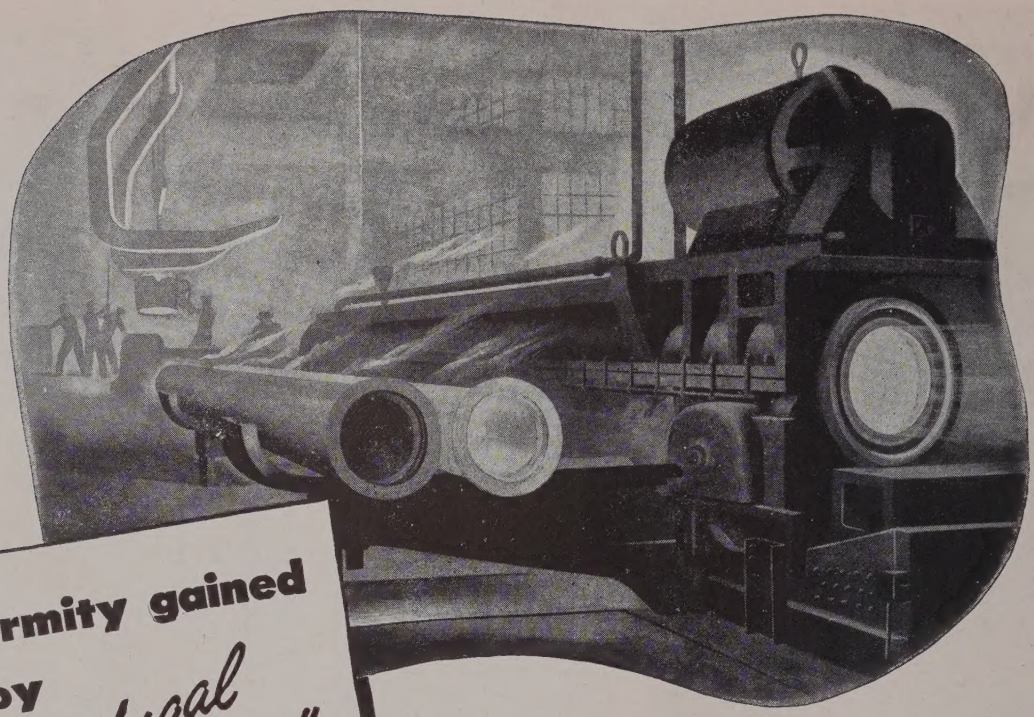
our cover

The steel industry, a very important aspect of the American scene, is depicted in this painting by Weimer Pursell for the National City Bank of New York who furnished the color plates.

our frontispiece

Electromagnetic models are a new method of determining transient voltages. Shown is a three-phase transformer and its electromagnetic model, aside of which is its inventor, P. A. Abetti. (Cut courtesy General Electric Company)



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Section of 114-year-old cast iron gas main still in service in Baltimore, Md.

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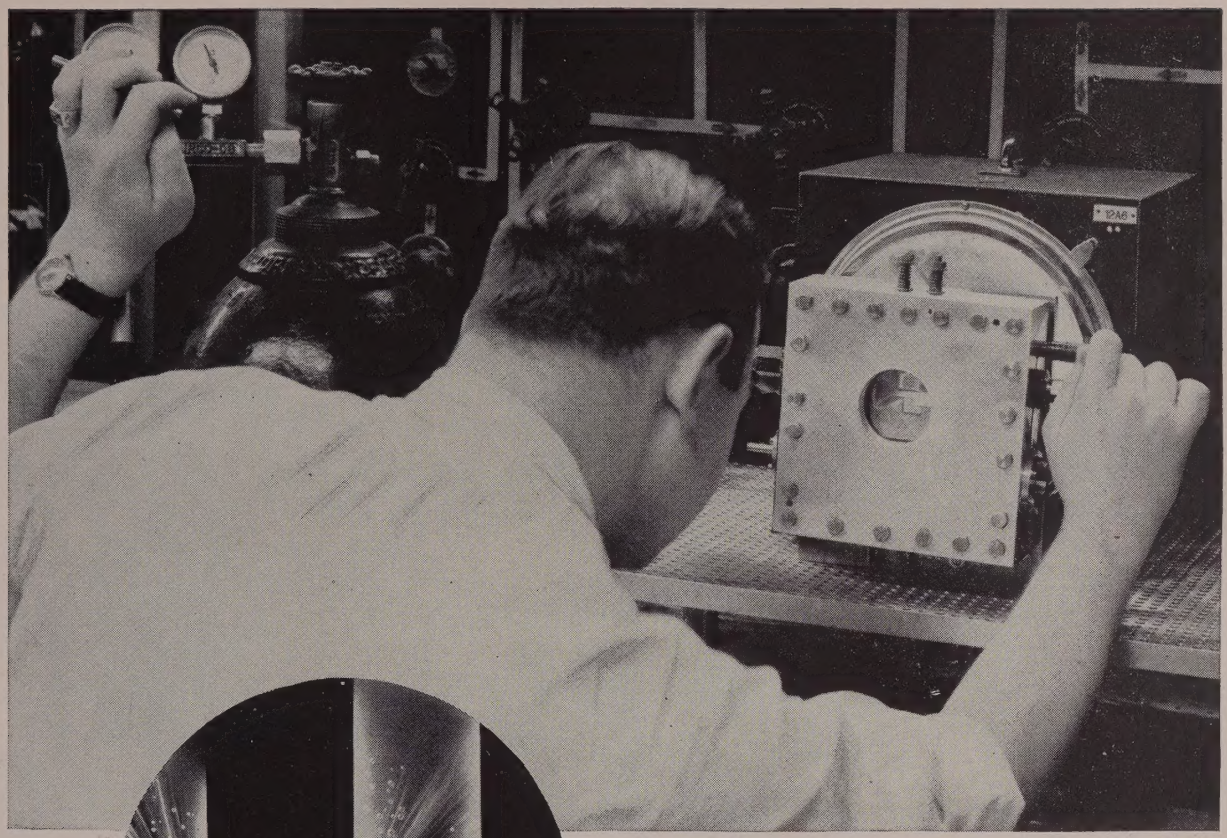

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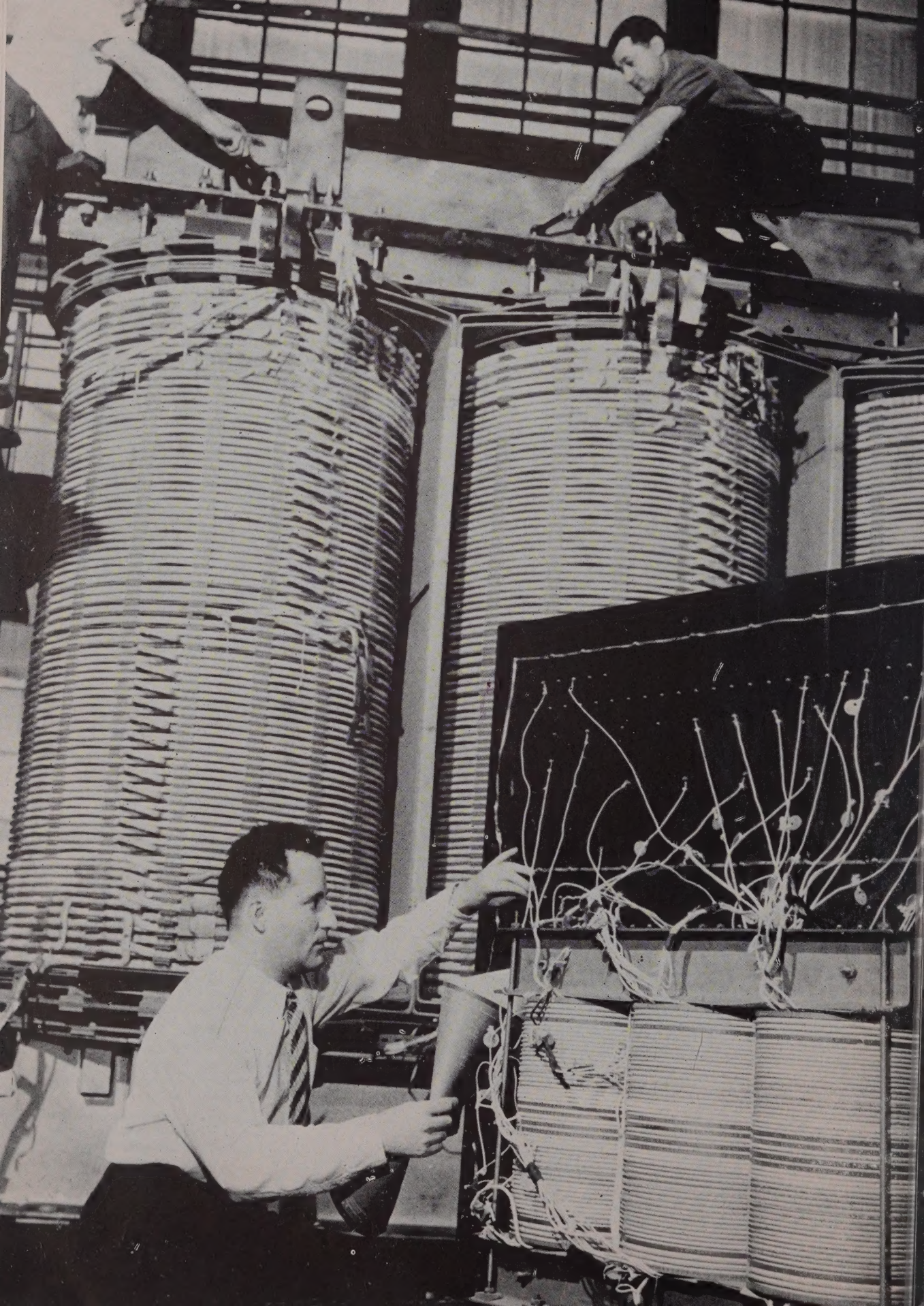


Fly Ash in Concrete

by Robert M. Koscielny, C.E. '54

Winner of the 1953 Dolly Gray award presented by the Mid-West Ready-Mixed Concrete Association was Robert M. Koscielny, a junior in Civil Engineering. The paper, which must be on a subject relating to ready-mixed concrete is presented below.

It has long been known that certain finely divided siliceous materials which possess no cementitious value will, in the presence of moisture, react chemically with lime, ($Ca(OH)_2$), at ordinary temperatures to form insoluble compounds possessing cementitious properties. Such a material is a pozzolan.

The four principal reactive compounds which are present in portland cement are tricalcium silicate, dicalcium silicate, tricalcium aluminate and tetra-calcium aluminoferrite. When portland cement combines with water, lime is liberated from some of these compounds. This lime combines with sulfates forming highly expansive and unstable calcium sulfate. Thus, by use of certain puzzolans it is possible to fix the lime into a stable and useful combination.

This introduces the important problem of selecting a pozzolan which is most suitable for the job. In this selection the properties which should be considered are strength, durability in resisting freezing-thawing and sulfate action, workability, shrinkage, and elasticity. Equally important is the net cost of the product.

The solution to this problem, at least here in the mid-west, seems to be a pozzolan, which is produced here in large quantities—known as fly ash. Fly ash is a fine powdered residue formed from the burning of powdered coal and is collected as a by-product in large power plants. This is collected by precipitators from the flue gases. It is of prime importance to note that there exists differences in chemical composition, but the principle compounds are silica, alumina, iron oxide, and lime. In all cases there exists some carbon. The carbon content is the critical compound. It is universally accepted that fly ashes of carbon contents that are less than 10 per cent, and of high fineness produce a greater activity and are a greater contribution to the strength of mortars and concretes.

It has been determined, that except for the carbon content, the differences in chemical composition have no marked effect upon the properties of concretes. In general, fly ashes of low carbon content are finer than those of high carbon content. The effect of the carbon content of fly ash upon compressive strength is shown in the table and graph below.

It is seen that fly ashes of low average carbon content exhibit a much higher strength at all ages than did the group containing the higher average carbon content.

A direct comparison of the effect of fineness was made between fly ashes having the same carbon content, and it was found that the cement containing the finer fly ash exhibited considerably higher compressive strength at all ages from 7 days to 1 year.

The graph and table further explain that at ages of 7 to 28 days the compressive strength was higher for the concrete containing no fly ash than for any of the concretes containing fly ash. However, at the ages of 3 months and 1 year the compressive strengths of the concretes containing fly ashes of low carbon content and high fineness were considerably higher than that of the ordinary portland cement concrete.

In an effort to eliminate this deficiency it has been found that if it is desirable to produce a concrete mix of 28-day strength equal to that of a comparable concrete without fly ash, the amount of fly ash used must be larger than the amount of cement replaced. For example, if 94 lbs. of cement is to be removed, as much as 150 lbs. or more of fly ash must be added to produce a concrete having a 28-day strength equal to the mix without fly ash. The amount of fly ash greater than 94 lbs. may be compensated by a reduction in sand.

This fact brings up a most important item—that of the replacement of cement by fly ash. The optimum replacement of cement depends on the nature and fineness of the fly ash, the richness of the mix, the type of cement, and the properties of the concrete desired. From a wide variety of tests and comparisons it has been concluded that the optimum percentage of replacement for most mixes may be 25 percent or more if a fly ash of low carbon content

Table[1]—Compressive Strength of Standard-Cured 1:5.6 Concrete Containing Fly Ashes of Different Carbon Content and Fineness. General-purpose Portland Cement; Portland-Pozzolan Cements.

Pozzolan in Cement	Per Cent Carbon in Fly Ash	Specific Surface sq. cm./gm. Pozzolan	Specific Surface sq. cm./gm. Cement	W/C of Concrete by Wt.	Compressive Strength of Concrete, p.s.i. 7 da.	28 da.	3 mo.	1 yr.
None	—	——	1600	0.43	4040	5310	5790	6810
Ave. for 3 fly ashes low in carbon	2	2750	1830	0.41	3520	4900	6090	7190
Ave. for 5 fly ashes high in carbon	22	2150	1710	0.49	2770	4030	5080	5870

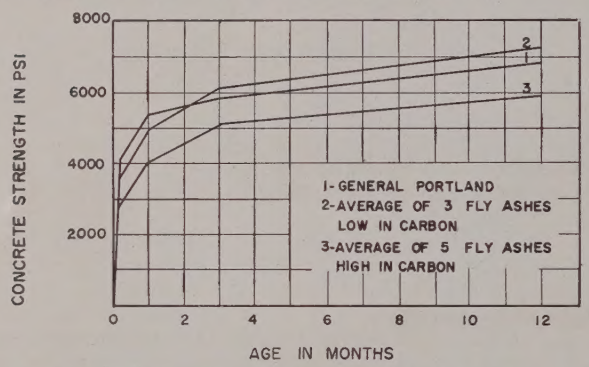
[1]Copied in part from *Journal of American Concrete Institute*, "Properties of Cements and Concretes Containing Fly Ash." R. E. Davis, R. W. Carlson, J. W. Kelley, and H. E. Davis. May-June, 1937.

and moderately high fineness is used. Such a replacement will produce a concrete which will have a compressive strength equal to or exceeding that which will be produced by the corresponding portland cement concrete.

Fly ash seems to contribute relatively more to the strength of lean mixes used in the construction of massive structures such as dams or bridge piers. Replacements as high as 50 percent have resulted in concrete strengths that were not unduly low and a substantial reduction in the heat of hydration making the possibilities of the use of high-replacement fly ash cement appear very attractive and for many purposes far superior to ordinary portland cement. Its current use in the construction of the Hungry Horse Dam proved satisfactorily that the use of fly ash has an important place in modern construction.

It is desirable that the amount of water required to produce concrete of given consistency be low. In this regard the desirability of a fly ash of reasonably low carbon content and high fineness is increased, in that, fly ash differs from most other pozzolans. Ordinarily a portland-pozzolan cement requires more water than the corresponding portland cement. This is illustrated in the table which shows that the water requirement was less for the average of 3 fly ashes low in carbon than for the corresponding port-

COMPARISON OF COMPRESSIVE STRENGTH OF CONCRETES CONTAINING GENERAL PORTLAND AND FLY ASH CEMENTS



land cement. Thus, the advantages of a low water requirement are added. These are: improved strength, watertightness, volume constancy, and improved workability on the basis of equal water-cement ratios.

Concretes in general tend to shrink upon drying. This characteristic is particularly undesirable in thin structures subjected to long drying conditions, since excessive shrinkage results in cracking. Drying shrinkage is related to the reduction of moisture content. It may, perhaps, be acceptable to assume that concretes containing fly ash cements possess finer pore space, moisture is less readily withdrawn from exposed surfaces. It is an accepted fact that the shrinkage of ordinary structures may be no more, and in some instances less, than for corresponding structures containing portland cement. A fact of further interest, is that generally the higher the strength of the concrete the less the contraction in fly ash cements.

In regard to the ability of concrete to resist the action of freezing and thawing, sulfate or sea water, and weakly acid or low $\not{p}$H waters, fly ash cements of low carbon content and high fineness seem to be equal and in many cases superior to ordinary portland cement. In the case of freezing and thawing, tests have shown that the compressive strengths of specimens treated were slightly less on the average for fly ash cements than for portland cement. However, a fly ash (Chicago fly ash) with the lowest carbon content and of moderately high fineness exhibited a higher strength than did the portland cement. Further, if air entrainment is used, the resistance to freezing and thawing is increased in both portland cements and fly ash cements to the extent that resistance to freezing and thawing has become almost unimportant.

Fly ash cements seem to be far superior to ordinary portland cement in their resistance to the action of aggressive waters. Thus, making the use of fly ash very desirable for concrete structures such as harbor works, sewerage or industrial tile, and bridge piers.

All fly ash cements generate less heat of hydration than portland cement. The rise in temperature due to this heat may cause stresses which are likely to produce cracks even in walls having a thickness no greater than 2 or 3 feet. Thus, again, indicating the necessity and desirable results obtainable by use of fly ash in massive concrete structures. In fact, concretes containing 50 per cent replacement by fly ash generate less heat than any other of the low heat cements employed in construction.

Tests determining the modulus of elasticity of concretes indicate that at early ages the modulus of elasticity for fly ash cements was slightly less than for portland cements. At later ages, it was somewhat higher. However, the differences were only slight and could hardly be large enough to become a factor of design.

Considering only the preceding discussion and noting the advantages of fly ash as a pozzolan, it is difficult for the author, at least, to see reasons for any resistance to its use. Perhaps, some resistance is induced because, as yet, long time tests have not been completed. Although, reports on tests now underway at various utilities, Federal bureaus, several state highway departments, and other such concerns have universally been good. Of course, there is a natural tendency to resist changing or tampering with a satisfactory product or process. Some poor results have been obtained with coarse high carbon content fly ashes. This fact indicates the necessity of an A.S.T.M. specification for fly ash. However, an A.S.T.M. Committee, C-9 on Concrete and Concrete Aggregates, is currently in the processs of evolving a specification for fly ash as an admixture.

However, when the items of cost of materials and saving of cement are added by the ready-mix concrete producer, these resistances seem to lose their significance. For instance, figures for the Hungry Horse Dam show that its use led not only to substantial improvements in the quality of the structure, but also to a tremendous savings of approximately $1,680,000 in the cost of materials used.[2] This saving is offset slightly by the cost of handling the extra material.

In ready-mix plants now handling bulk fly ash the installation and cost of equipment to handle the fly ash has ranged from 4 to 6 thousand dollars. This equipment includes a silo and the necessary valves and conveyors to handle the fly ash. The cost of transportation is usually greater than the cost of fly ash. Assuming a portland cement replacement of 25 percent, and the cost of fly ash delivered to be $5.00 per ton, and the cost of portland cement delivered to be $15.00 per ton. The savings here in total cost of material per one hundred tons of portland cement used without fly ash is $250.[3] On the basis of a six bag mix the cement without fly ash would cost $4.50 per cubic yard of concrete. If a 25 percent replacement is used, the cost of cement per cubic yard of concrete would be only $3.35. This represents a savings of $1.05 per cubic yard of concrete.

The conclusions regarding the suitability, quality, and economy of the use of fly ashes of moderately high fineness and low carbon content in concretes follow:

1. Compressive strength is increased considerably.
2. The heat of hydration is reduced.

[2]R. E. Blanks, "Fly Ash as a Pozzolan," *Journal of the American Concrete Institute*, Vol-. 21 (May, 1950), pp. 701-7.

3. The water requirement for a given workability seems to be nearly the same or slightly less.

4. Resistance to sulphate action and aggressive waters is increased.

5. Modulus of elasticity is affected, but is not of sufficient magnitude to be a factor of design.

6. Shrinkage is no more and in many cases less.

7. Resistance to freezing and thawing is slightly reduced.

8. More air entrainment admixture must be added to obtain the same amount of air entrainment.

9. The cost of materials is reduced a tremendous amount.

10. Less portland cement is required.

11. Richness of the mix has little or no effect on the contribution of fly ash to the compressive strength.

From these conclusions it seems only logical to state that the use of fly ash has definitely improved the concrete product, and does have an important place in modern construction.

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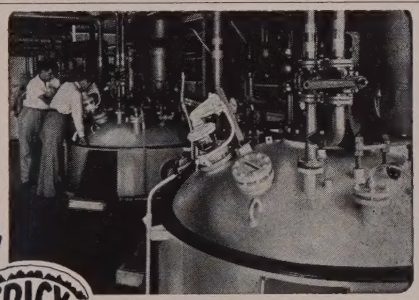
Synthetic Rubber Industry Increases Output with



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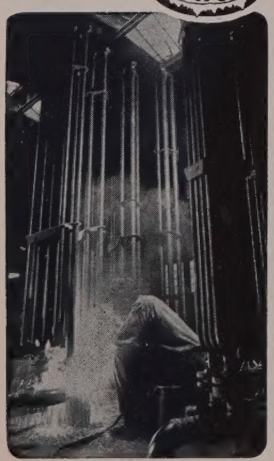

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The Physics

collected and edited by C. Han Sah, Eng. Physics,

To conduct a program of research successfully, regardless of the field, at least two items are obviously needed: (1) equipment or tools which are reliable and accurate and (2) competent personnel to organize and supervise the research. At the University of Illinois, physicists are fortunate in that they find neither item lacking. In fact, Illinois is one of the very few places where there is a large group of instruments available so that a complete investigation can be carried out in almost every field of nuclear physics. Also, many of the staff members of the Physics department are considered to be among the world's foremost authorities in their respective fields.

Everyone has probably heard about the University of Illinois's betatron at one time or another. A great deal of public interest has centered about this important tool of physics since it is the largest type of accelerator of its kind in the world. However, it would indeed be a mistake for one to think that it is the only (or even the most important) center of research activity. Actually, there are many programs which are being carried out simultaneously in widely scattered areas on the campus, all of which are of great importance. In order to cover these various research programs, we must necessarily limit ourselves to a glimpse of only the salient features of each.

NUCLEAR MAGNETIC RESONANCE AND NUCLEAR ALIGNMENT

Dr. C. P. Slichter is presently conducting an experiment on nuclear magnetic resonance. In order to understand the fundamental principles underlying this experiment, one must realize that the nucleus of an atom can be considered to act like a tiny magnet. When a nucleus is placed in a static magnetic field, the interaction of its magnetic moment with the static field gives rise to a phenomena known as the nuclear Zeeman effect. The "spectral lines" which are emitted by the excited nucleus split up into several components known as Zeeman levels. Transitions between the different Zeeman levels can be produced by alternating magnetic fields whose frequency in typical cases, is a few megacycles/sec. Since the frequency depends, among other things, on the strength of the nuclear magnet, one can in this manner measure nuclear magnetic moments. When transitions occur between the Zeeman levels, "spectral lines" are in many cases observable. These lines are of considerable interest since the line breadth results from interactions of a nucleus with its environs. Usually one is using a liquid or solid sample, in which case these environs include other nuclear magnets, electrons either tightly bound to the nucleus or (as in metals) wandering through the solids, etc. These interactions are strongly characteristic of the particular sort of material (solid, liquid, metal, ionic crystal, etc.) containing the nucleus. Interpretation of features of the nuclear resonance enables one to use the nuclear magnets as tiny probes to study liquids and solids. Such things as coefficients of self-diffusion, onset of internal motion in solids, etc. have been studied in this manner. Currently at Illinois, work is being carried on studying resonances in the alkali metals (where self-diffusion affects the resonances dramatically) and in super-cooled liquids. A new program to study magnetic resonance of electron magnetic moments has recently been started.

Doctors J. C. Wheatley and R. D. Hill are presently engaged in determining nuclear spins and magnetic moments by a method known as nuclear alignment. Although this is a difficult method, it may be the only way of determining these quantities directly for radioactive nuclear levels.

The present equipment consists of a cryostat using adiabatic demagnetization. A magnet developing 15,000 gauss in a volume of approximately 100 cc has been used for the demagnetization experiments. The cryostat is jacketed with liquid N_2, liquid H_2, and liquid He, in that order. Temperatures of 0.03 degree Kelvin have thus far been achieved. Four scintillation counters for simultaneous gamma ray intensity measurements are set up around the nuclear-aligned single crystal.

RADIOACTIVITY RESEARCH PROGRAM

Radioactivity experiments are being conducted by Doctors R. D. Hill, P. Axel, I. Bergestrom and H. Frauenfelder. These experiments are directed at determining the properties of excited states of nuclei. The interest in these properties is widespread for two reasons: (1) the experimental techniques are sufficiently developed so that many characteristics of excited states can be determined unambiguously. (2) There are several partially successful theories which can be tested or revised on the basis of regularities which can be found in the experimental data.

There are many experimental measurements which can be made to help determine the properties of nuclear energy levels. For any given radioactive nucleus, the use of several of these experimental techniques can give a complete picture of the radioactive decay.

The equipment which is used by this group includes five different types of beta ray spectrometers plus a wide assortment of scintillation detectors and proportional counters. There is also auxiliary electronic equipment which makes it possible to detect radiations simultaneously.

With this equipment it is possible to determine the following data, from which the properties of nuclear energy levels can be inferred: (1) The energy, intensity and energy distribution of positive or negative beta particles. (2) The energy and intensity of conversion electrons. (3) The energy and intensity of gamma rays and x-rays. (4) The simultaneity (or coincidences) of any pair of radiations or the time delay between these radiations. (5) The relative angular distribution of two radiations which occur successively.

RESEARCH PROGRAMS AT THE PHYSICS RESEARCH LABORATORY

The Physics Research Laboratory houses the three University of Illinois betratons. Although the 300 Mev. betatron is the one which one hears about most often, much important research has also been carried out utilizing the 80 Mev. and 20 Mev. machines. The laboratory is well equipped for experiments with scintillation counters, photographic emulsions, cloud chambers, and chemical separation techniques. The machine shop and glass shop facilitate construction of equipment.

20 Mev. Betatron

The 20 Mev. Betatron is an instrument for accelerating electrons up to accurately known continuously variable energies. This betatron can be used in any one of three different ways: (1) with a standard x-ray tube, it can pro-

Department

and Henry Kalapaca, N.R.L.

duce a source of x-rays. (2) the electron beam can be used to bombard internal targets directly or (3) the electron beam can be removed from the betatron and utilized outside the machine.

Research with the 20 Mev. machine can be also classified into three groups. (1) A great deal of the work has centered about the detailed study of how photons (bundles of light energy) are absorbed by the nuclei of uranium atoms and what happens to these nuclei after the absorption. (2) By placing suitable targets directly into the electron beam, it is possible to obtain sufficient intensities of radioactive materials to obtain good sources for the study of decay schemes. Dr. Duffield in collaboration with others, has studied the decay scheme in In, Ag, Ta and W and at present, is studying the isomers of Mo^{91} and has plans to look at Vanadium. (3) The electrons from the betatron can be focused, by means of a magnetic lens, to a small spot at about 10 feet from the machine. This beam has been used for preliminary studies of electrodisintegration of nuclei but primarily for studies on the scattering and energy loss of electrons in matter. The most recent work with the electron beam has been that of Goldwasser, Mills, and Robillard who have obtained very nice data on the comparison of the energy loss in gases and solids of the same composition.

The 80 Mev. betatron operates with one burst of x-rays every three seconds or less frequently. As such, it is valuable for cloud chamber studies and for testing apparatus.

300 Mev. Betatron

The 300 Mev. betatron provides a very intense and highly collimated beam of x-rays, the maximum energy of which can be controlled accurately and conveniently between 100 and 340 Mev. Measurements of small cross sections, of angular distributions, and of energy dependence of nuclear processes thus can be performed with some precision.

Several members of the betatron staff are studying the structure of nucleons through meson production by x-rays in hydrogen. (Nucleons are the particles which constitute the nuclei of the atoms). By measuring the energy and angle of the meson or of the recoil nucleon, one can completely determine the dynamics of the process. With the uses of liquid hydrogen targets, Doctors Goldwasser and Bernardini have already made considerable progress in this area of research.

The liquid hydrogen targets have also been used by Whalin, Dwight, Hanson, Kerst, Smith and Koester to study the photodisintegration of deuterium (heavy hydrogen) at high energies. Photodisintegration studies of heavier nuclei reveal much information about nuclear structure, and is also being studied by several staff members.

In the field of electrodynamics, Fisher has done a cloud chamber experiment on high energy scattering of positrons and electrons.

NUCLEAR RADIATION LABORATORY

The Nuclear Radiation Laboratory houses the University's cyclotron. Although not widely publicized, some of the most fundamental and vital research has and is being conducted there. Cyclotrons have been known since their invention to be nearly as complicated and sensitive as women, but in the last few years many cyclotrons, including ours, have changed, and now work as any good physical instrument should work.

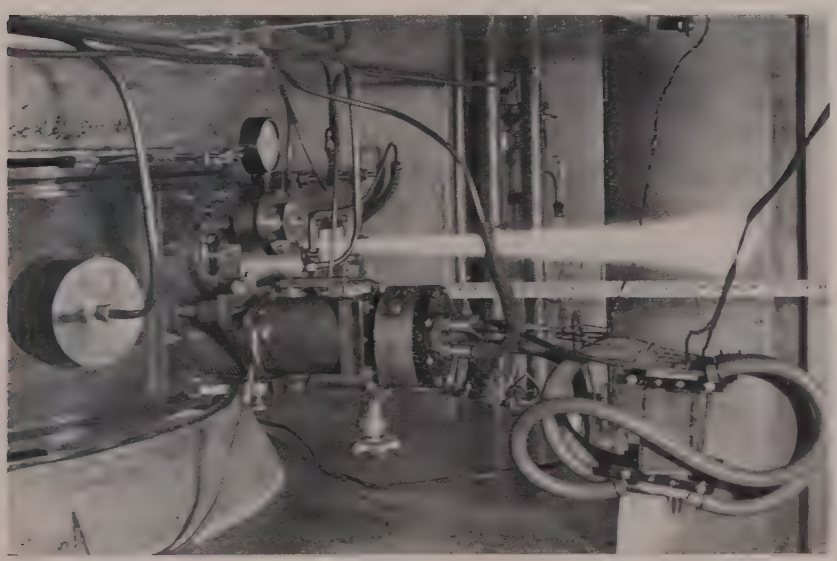
The basic problem underlying almost all of the experimental investigations is the structure of the atomic nucleus and the laws governing it. The beam of the cyclotron is especially suited to this work, with 6 Mev. protons, 12 Mev. deutrons, or 24 Mev. alpha particles available. Despite the fact that this branch of nuclear physics (the "classical nuclear physics") is much older than the high energy field, recent developments in instrumentation have opened up new possibilities for fundamental research.

The laboratory has its own well equipped machine shop, a large variety of electronic instruments, and equipment for nuclear emulsion and other photographic work.

Recently, a program supervised by Dr. P. G. Kruger and Dr. W. K. Jentschke consisting of precision elementary particle scattering has been successfully concluded with alpha-alpha and deutron-proton experiments.

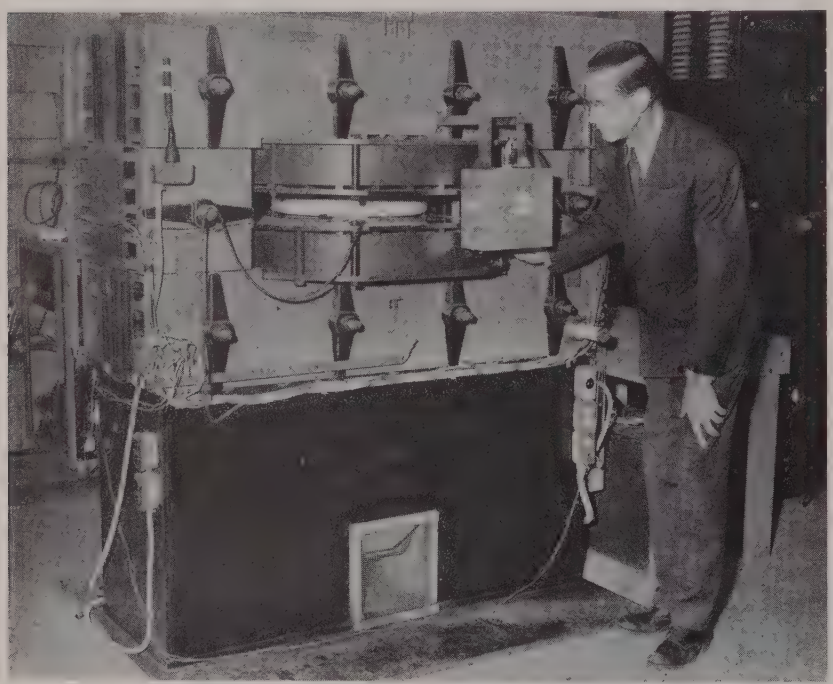
One of the main investigations headed by Dr. H. Frauenfelder at the present time is the directional correlation of nuclear radiations. The basic problem of these investigations is very simple: a nucleus emits in rapid succession two radiations, e.g., two gamma-rays. Does the second gamma-ray know in which direction the first has been emitted? Theory predicts that it does, and that the result of a measurement of the correlation between the two radiations can be used to gain information about important properties (quantum numbers) of the nucleus.

The first investigations were carried



Ten mev deuterons emerge from the U. of I. Cyclotron. (Photo courtesy of Nuclear Radiation Laboratory)

out 5 or 6 years ago and the method developed into a standard measuring procedure. Two years ago, however, it was discovered that the nuclear angular correlation can strongly be influenced by external means, e.g., the field of the atomic shell or external magnetic fields. These effects are interesting because of the following reasons: (1) The influence of the electron shell and of the surroundings of the radioactive nucleus on the directional correlation introduces atomic and solid state physics into this part of nuclear physics. This coupling of different parts of physics makes the investigations more difficult, but it provides the possibility of attacking many interesting problems in atomic, nuclear, and solid state physics, which are very difficult to reach from other directions. (2) The fact that the directional correlation can in some cases be influenced by external magnetic fields allows the measurement of the magnetic moments of excited nuclear levels. This important property escaped formerly all methods.



Professor D. W. Kerst, builder of the first successfully operating betatron, inspects the 20 mev betratron. (Photo courtesy of the Physics Research Laboratory)

A fascinating experiment which is now being done by Doctors J. S. Allen and W. K. Jentschke and others is an investigation of the role played by the neutrino in the decay of radioactive nuclei. The neutrino is a particle postulated by physicists to account for the energy loss in some nuclear transformations one of which is the beta ray decay of nuclei. The neutrino is supposed to carry no charge and to have a very small mass, hence it can pass unhindered through miles of matter. For this reason, no one has directly observed neutrinos experimentally.

At Illinois, the experimenters hope to establish the type of interaction responsible for beta ray decay. In general, the experiments require the determination of the form of the angular correlation between the directions of emission of the beta ray and recoiling nucleus. The beta rays are detected with a scintillation counter and the recoil nuclei are counted with a special electron multiplier tube. In order to obtain very thin sources, radioactive gases at low pressures have been used.

SOLID STATE PHYSICS

The solid state physics research group at the University of Illinois is considered to be one of the finest such groups in the world. Heading the staff are Professors Bardeen (co-inventor of the point-contact transistor), Seitz, Koehler and Maurer. A discussion of some of the various phases of research follows.

Plastic Deformation of Crystals and the Radiation Damage of Solids. Dr. J. Koehler is presently working in the field of plastic flow in metals. This deformation research is interesting in that the experimental results are behind the theoretical work. The dislocation theory is very rich and for each phenomena observed there are usually several explanations offered. Hence, there are many critical experiments being conducted in the attempt to clear up the ambiguity.

The study of the imperfections produced in solids by fast particle irradiation has already provided new information of value to those interested in the solid state. For example, it has been demonstrated that these imperfections speed diffusion. The research program in this field at Illinois is aimed at obtaining a basic understanding of the production, the nature, and number of such defects, and of their behavior during annealing. The damage experiments done here thus far have already given information of value concerning diffusion, concerning the types of defects produced during cold-work, and concerning the influence of impurities on self diffusion. Thus, radiation damage studies constitute a powerful tool for solid state research. Dr. Overhauser is presently in charge of this experiment.

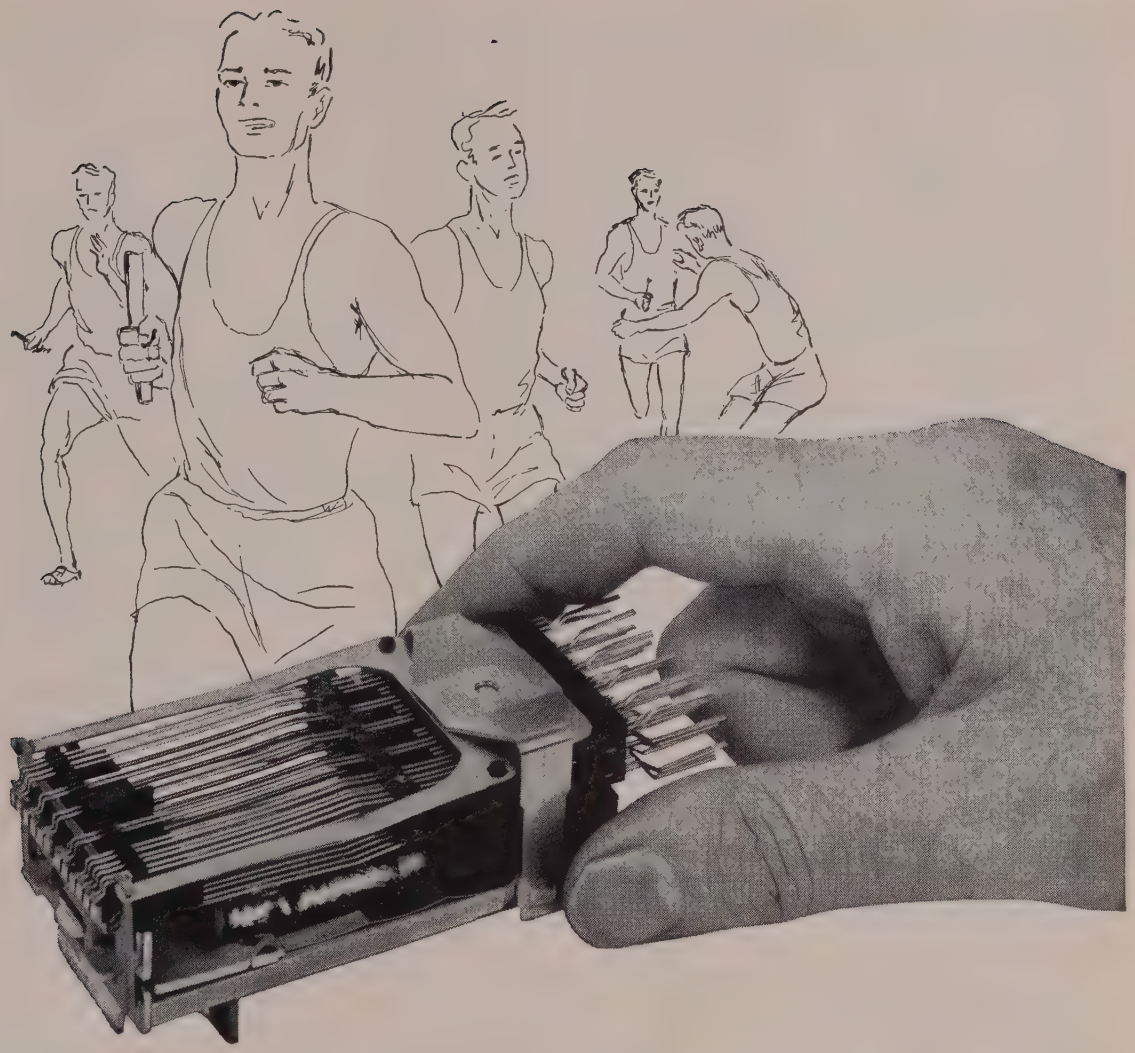
Semiconductors and Transistor Electronics. Semiconductor and transistor electronics research is being conducted in the Department of Electrical Engineering under the supervision of Dr. J. Bardeen. The general aim of the program is to learn more about fundamental properties of semiconductors, with emphasis on those which may be important for diodes and transistors. Present work is concerned with surface properties of germanium, an electrolytic analogue of a transistor, properties of fused junctions and internal friction and diffusion in germanium. Professor Murrell is directing a separate but related program on the semiconducting properties of lead telluride.

Low Temperature Research

The principal item of large equipment used here in connection with low temperature research is a Collins Helium Cryostat. This helium liquifier can produce about five liters of liquid helium per hour. Of course, facilities are available for storing liquid helium and transporting it to remote experimental stations.

Liquified helium boils under atmospheric pressure at a temperature of 4.2°K or -454°F. By pumping off vapor from the liquid helium, temperatures as low as 0.77°K have been obtained, though temperatures much lower than this may be obtained through other means.

Using liquid helium, investigations are being made of superconductivity. This is a phenomenon which occurs in some metals at very low temperatures. The most striking effect of this phenomenon is the sudden drop of electrical resistance of the metals at a certain temperature, which is different for each



A NEW RELAY RECORD

RELAYS—which are high-speed switches—are the nerve centers of the dial telephone system. In a split second, they set up a connection and then are off to direct the next call. In a large city, more than 1000 relays are used every time a number is dialed.

Now a new wire spring relay—devised by the Bell Laboratories—is at work. With only 11 instead of 70 parts, it is twice as fast, uses less power, and costs less to make and maintain than its predecessor. Result: calls go through faster and switching is done with less equipment.

Men and women of the Bell System—in operating, manufacturing and laboratory work—continually seek new ways to improve telephone service. Qualified engineering graduates can find well-paid and interesting careers in the telephone business. Your placement officer can give you details about opportunities for employment in the Bell System.

BELL TELEPHONE SYSTEM

superconductor. (For alloys as high as 15-16°K, for pure metals around 8°k and lower). Below this transition temperature, the resistance drops to zero; at this point many very interesting and striking effects are observed. For example, one of the effects observed is the floating of a superconductor above a magnet without any mechanical support. This is explained by the fact that the superconductor will not allow any magnetic field to pass through, and the result is that the superconductor will "sit" on top of the magnetic field due to the magnet. However, the fundamentals of superconductivity are not well understood even after forty years of work.

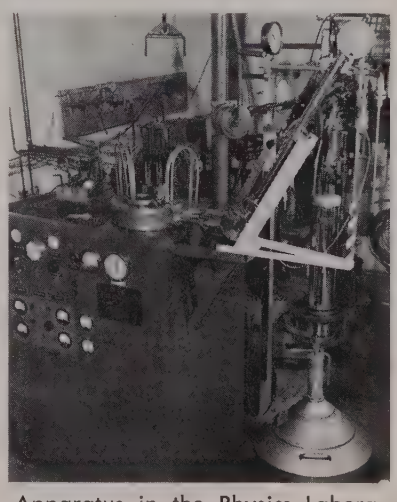
Outside the study on superconductivity, the properties of liquid helium itself are also being studied; for associated with liquid helium, there are many remarkable phenomena which can not be observed with any other liquid. When liquid helium is cooled below 2.19°K (the lambda point of liquid helium), a phase transformation of the normal helium occurs. The result is the formation of a new liquid phase (usually called Helium II). Helium II has properties that are strikingly different from the Helium I, the ordinary helium, or any other liquid. Of these properties Rollin film effect is one of the more remarkable. In this effect the liquid helium is observed to flow against gravity up the side into a container, when the container is lowered into a bath of liquid helium.

In another investigation, study is being made of the properties of matter at extremely low temperature (of the order of 0.01°K). In order to make such a study, some methods in addition to pumping off vapor from liquid helium must be employed. Here a method called "adiabatic demagnetization" is used. In this method a paramagnetic material (a material whose atoms behave like small magnets) is cooled to helium temperature by suspending it in a vacuum bottle and surrounding the bottle with liquid helium. Helium gas is allowed to pass in and out of the vacuum bottle to serve as a conductor of heat. A vacuum pump is used to obtain a temperature of about 1°K. After this an external magnetic field is applied to line up the "atomic magnets" of the material. During this process of magnetization, the material will heat up due to the forced orientation of the atomic magnets. The heat developed is absorbed by the surrounding helium, some of which is boiled off. Then the vacuum bottle is sealed, after the helium gas inside is pumped away. Next the external magnetic field is cut off. During this process of demagnetization— by cutting off the external magnetic field — the paramagnetic material will cool the whole volume inside the vacuum bottle. The resulting temperature may be as low as a few thousandths of a degree Kelvin. In this way the study of the properties of matter at these extremely low temperatures is made possible.

These are some of the research projects in the field of low temperature physics; of course, several other projects are being conducted in conjunction with other groups both in and out of the physics department.

Biophysics and Photosynthesis

A number of biophysical investigations centered about the interaction of light with biological systems are being carried out in the physics department by Dr. Rawcliffe and in the photosynthesis laboratory of the Botany Department by Dr. Emerson and Dr. Rabinowitch. Among these are the following: (1) The absorption of light, as in photosynthesis starts a chain of reactions and various intermediates are formed in rapid succession. The rapid changes in the absorption spectra which occur are being studied to find information which will help unravel these processes. (2) Many of the key chemical constituents of cells are concentrated in definite locations within the cell. If the chemicals at the various locations can be identified valuable clues will be provided to the function of these chemicals in the cell. A micro-spectrophotometer is nearly completed. It will be used principally for the above chemical identification. It is expected to be useful also in the study of the interactions of molecules in microcrystals, etc., discussed under (4). (3) The efficiency with which a plant converts light energy into chemical energy, i.e., the quantum yield of photosynthesis is of great importance both because of its practical aspect and because it can provide information essential to the formulation of any theory of the photosynthetic process. A rather violent controversy exists regarding the true value of the quantum yield. Measurements are being made here in an effort to tie down unequivocally this vital quantity. (4) When colored molecules are closely packed as in crystals or as in pigment centers in plants, interesting interactions occur which are important in photochemical reactions such as photosynthesis since they lead to exchange and migration of excitation energy. The changes in the absorption, fluorescence and light scattering are being studied as molecules condense into microcrystals and monolayers, in order to obtain a better understanding of these intermolecular interactions.



Apparatus in the Physics Laboratory used to generate liquid helium. (Photo by Bob Feldman)

Electrode Physics

This project, headed by Dr. J. H. Bartlett, is concerned with the changes which can occur on or near an electrode immersed in a solution. One of the experiments dealt with a copper anode in an HCl solution. The experimenters found that a solid layer formed on this electrode, and that concentration changes occurred in the solution immediately adjacent (within .05 cm) to the electrode. They took microphotographs of the electrode and now know how the layer grew. They also devised optical methods for studying the variation of the index of refraction of the solution, both as a function of space and of time.

Their present task is to integrate all the data that they have, both electrical and optical, into one consistent picture and to test this picture in general. Such a picture will be of enormous value in clearing up the mechanisms of rectification, electropolishing, passivity, periodic current oscillations, corrosion, and even of such a seemingly unrelated process as the conduction of an impulse along a nerve.

Helium Wave Equation

This project, also headed by Dr. J. H. Bartlett, has as its problem the finding of a solution, accurate to about one part in 100,000, of the wave equation of the helium atom. This is desired both for the ground state and the first excited state. When done, it will provide (1) the first accurate solution of a many-body problem, and (2) information about the He^3 nucleus, the magnetic moment of which has been measured.

Before this investigation was started, there were no successful attempts to find a wave function for helium. However, the problem is now being coded for the Illinois digital computer. When the present approximation has been run on the machine, the results will be analyzed with the aim of developing still more powerful and precise methods.

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CIVIL ENGINEERING RESEARCH

by the Research Staff—Civil Engineering Department

Structural research here at the University of Illinois involves work in the laboratory, theoretical studies, and computations. To get any idea of the work going on in structural research, all one has to do is see the massive machines of Talbot Lab in action. Here tests are continually being run on steel and concrete members.

One long range project is the tests being made on pre-stressed concrete. Beams are made of concrete, which is high in compressive strength but low in tensile strength, with high strength steel rods added which are under a high tension. Load stresses on the beam will then be canceled by the pre-stresses in the rods. Such beams show little signs of cracking while under working loads.

These beams as any other beam can fail in either of two ways. There can be a failure in flexure or in shear. In the first case the beam fails either under tension in the lower half where it would pull apart, or it fails in compression above the neutral axis where it would crumble. In the second case the beam will shear or break apart vertically.

The purpose of testing these beams that is now being carried on is to find the ultimate load that the beams will carry. The concrete, number of rods and pre-stress in the rods are varied. The loads that will cause failure in flexure and those that will cause shear are both determined.

From these ultimate loads a safety code is made. In practice the beams are made to fail in flexure rather than in shear. The reason for this, that cracking will precede a failure in flexure, while a shear failure gives no warning.

A project for testing reinforced concrete eccentric loaded columns is also being carried on. An eccentric loaded column is a member that has a load applied to it at a point that is not on the axis of the column. Such a column contains a bending stress. It is surprising that 99% of all columns are eccentrically loaded, yet the present codes for such columns are based on judgment rather than facts. It is for this reason that tests on eccentrically loaded columns are now being run.

The tests are divided into static tests and continuous loading tests. In the first, the stresses are increased until the ultimate loads are reached. In the second a constant load is applied for a long period of time. Under such a condition the concrete will tend to "creep."

Fatigue in plain concrete is also a research project under way. Four-foot beams of various strength concrete have a repeated load applied to them until they fail. These tests show that the limiting load that can be repeated a certain number of times will be the same percentage of the maximum load, regardless of the concrete strength. It is also shown that a sufficiently small load may be repeated indefinitely without causing failure.

The fatigue of steel columns in compression is another project in structures research. The compression on small steel columns is repeatedly varied from 500 to 30,000 pounds per square inch until they fail. From these tests the fatigue in full-sized columns can be determined.

A long-time project that has been carried on in connection with the railroads is the study of fatigue in rails. This is a full scale project with huge wheels being passed back and forth over various sizes of rails.

Other projects in structural research are being carried on to find the ultimate loads of riveted and welded joints, the fatigue in these joints, ultimate loads of copper connections, stresses in knee braces and fatigue in concrete slabs.

All of the research of the structural stresses consists of tests on simple structural elements. These results are then used to calculate the stresses in the larger structures of the field.

Hydraulic Engineering Research

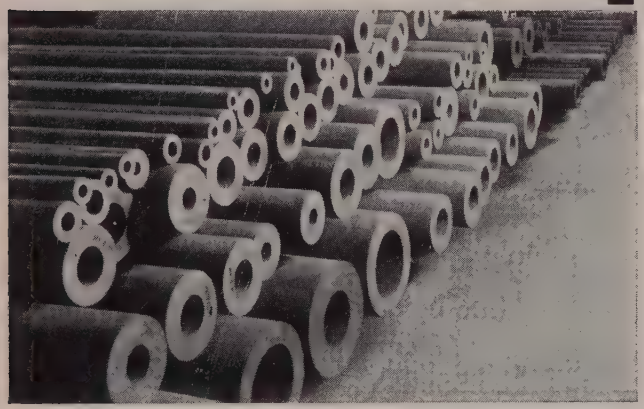
The Civil Engineering Department has well-developed facilities for research in Hydrology and Hydraulic Engineering. Present programs include both laboratory and analytical studies. Laboratory investigations are accomplished through model studies and analysis of data derived from model tests. A program on highway drainage is now nearing completion. With the cooperation of the Illinois Division of Highways and the U.S. Bureau of Public Roads certain phases of drainage problems related to super-highways or expressways were studied with a view to study the special problems which arise in connection with this type of highway.

Some expressways are depressed below the level of the surrounding terrain. All of the precipitation is therefore trapped in a long and very narrow excavation. The problem is further complicated by the fact that in order to reduce excavation costs the roadway grade is kept at a higher elevation between street crossings and lowered to provide the necessary vertical clearance under bridges. This gives a sort of roller coaster effect to the finished roadway. In addition, sloping ramps are required to provide access to the expressway at certain designated points. The very nature of the purpose of an expressway requires that probable traffic interruptions due to flooding must be kept at a minimum so that adequate drainage facilities must be provided. The problem involves determination of: gutter capacity; provision of efficient grate sections capable of intercepting the volume of water, determined by the inlet spacing; size of inlet boxes or catch basins and drains to carry the water from the inlets to the main drain. Since the cost of an expressway drainage system is necessarily quite high, research activities can be justified because they reveal ways and means by which costs can be reduced. Highway

What's Happening at CRUCIBLE

about hollow tool steel

Crucible is now making its high quality tool steel available in hollow form. Bars of Crucible Hollow Tool Steel can now be obtained with machine finished inside and outside diameters and faces — in three famous grades: KETOS, AIRDI 150 and SANDERSON. Already its use has effected substantial savings for makers of tool steel parts with cutout centers.



typical applications

The ring shaped tools that can be fabricated from hollow tool steel are virtually limitless — beading rolls, bearings and bushings, blanking and briquetting dies, cam dies and followers, chuck jaws, circular knives and shears, cutters, die holders and inserts, engraver and edging rolls, extrusion dies, feed and flue rollers, forming rolls, nozzles, saws, sleeves, slitters, stamping dies, wheels . . . and many others.

how it cuts costs

Crucible Hollow Tool Steel permits a toolmaker to bypass drilling, boring, cutting off and rough facing operations. Naturally, this results in less production time per unit, greater machine capacity, and a reduction in scrap losses. In some cases material costs alone are cut 20% by the use of Crucible Hollow Tool Steel instead of regular bar stock.

availability

All grades and sizes of Crucible Hollow Tool Steel are carried in stock in Crucible warehouses conveniently located throughout the country.

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Sizes (inches)	GRADES		
	Sanderson	Ketos	Airdi 150
2 O.D. x 1 I.D.	x	x	
2½ O.D. x 1½ I.D.		x	
3 O.D. x 1½ I.D.		x	
3¼ O.D. x 1¼ I.D.	x	x	x
3¼ O.D. x 1½ I.D.		x	
3½ O.D. x 1½ I.D.	x		
3½ O.D. x 2 I.D.	x	x	x
4 O.D. x 1½ I.D.			x
4 O.D. x 2 I.D.		x	x
4¼ O.D. x 1¾ I.D.			x
4½ O.D. x 2 I.D.	x		x
5 O.D. x 2 I.D.	x	x	x
5 O.D. x 2½ I.D.		x	x
5 O.D. x 3 I.D.	x	x	
5½ O.D. x 1¾ I.D.			x
5½ O.D. x 2 I.D.		x	
5½ O.D. x 2½ I.D.	x		x
6 O.D. x 1¾ I.D.			x
6 O.D. x 2 I.D.		x	
6 O.D. x 3 I.D.	x	x	x
6½ O.D. x 3¼ I.D.			x
6½ O.D. x 3½ I.D.		x	
6½ O.D. x 4 I.D.			x
7 O.D. x 2¼ I.D.			x
7 O.D. x 3 I.D.	x	x	
7 O.D. x 3½ I.D.			x
7 O.D. x 4 I.D.	x	x	
7½ O.D. x 3 I.D.	x	x	
7½ O.D. x 3½ I.D.	x	x	
7½ O.D. x 4 I.D.			x
8 O.D. x 3½ I.D.	x	x	
8 O.D. x 5 I.D.	x	x	x
8¼ O.D. x 3½ I.D.			x
8½ O.D. x 5¼ I.D.	x	x	x
9 O.D. x 4 I.D.	x	x	
9 O.D. x 5 I.D.		x	x
9 O.D. x 6 I.D.	x		
10 O.D. x 4 I.D.		x	
10 O.D. x 5 I.D.	x	x	
10 O.D. x 6 I.D.	x	x	x
11 O.D. x 4 I.D.	x	x	
11 O.D. x 6 O.D.	x	x	
11 O.D. x 7 I.D.		x	x
12 O.D. x 5 I.D.	x	x	x
12 O.D. x 6 I.D.	x	x	
12 O.D. x 7 I.D.	x	x	
12 O.D. x 8 I.D.		x	
13 O.D. x 6 I.D.		x	x
13 O.D. x 7 I.D.	x	x	
13 O.D. x 8 I.D.			x
13 O.D. x 9 I.D.		x	
14 O.D. x 7 I.D.	x	x	x
14 O.D. x 10 I.D.		x	
15 O.D. x 9 I.D.		x	x
15 O.D. x 10 I.D.		x	
16 O.D. x 10 I.D.	x	x	x
16 O.D. x 12 I.D.	x	x	

technical service

If you make tools with machined-out centers and wish additional information on Crucible Hollow Tool Steel, or technical assistance in solving an application problem, call in a Crucible representative. Our experienced staff of tool steel specialists is always available.

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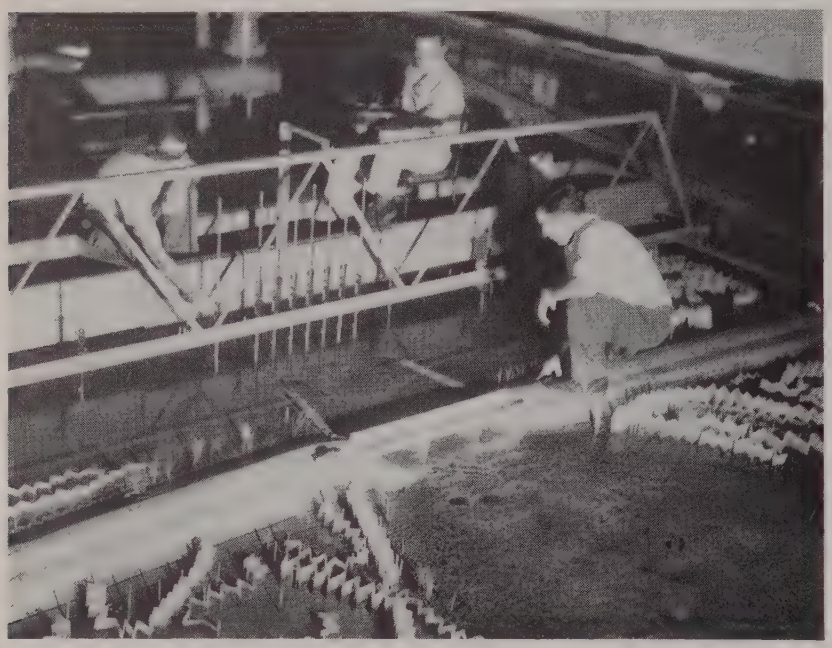
drainage practice in the past has been more or less traditional and engineers have come to realize that what may have been satisfactory in the "horse and buggy days" is not suitable or economical for modern traffic.

A second research problem which is of a purely analytical nature deals with "Frequency Analysis of Hydrologic Data." This study includes an analysis of rainfall amounts, intensity or rate of fall in inches per 5 minutes, 10 minutes, etc., and recurrence interval, 2 years, 5 years, etc., up to 50 years. Results of this study are usable in other investigations. A University of Illinois Experiment Station Bulletin reporting the results of this project is now in press.

A third problem concerns the "Hydraulics of Flow at Bridges." This study consists of determining the effect of flood flows around bridge piers and abutments for the purpose of avoiding erosion of the earth channel above, under and below the bridge. A model study of an overflow bridge on the flood plain of the Wabash River in Illinois was completed recently. This study was undertaken to detect methods of correcting an existing dangerous condition. Other specific bridges are now under study and it is expected that design criteria will be developed for use in connection with proposed new bridges.

Another current research investigation deals with the "Determination of Waterway Areas" for bridges and culverts for highways. This problem involves both hydrologic and hydraulic analysis which will develop a simple but scientific solution of a problem which heretofore has received relatively little attention when its importance to the economy of construction costs and safety of operation are considered.

A number of other research projects dealing with urban drainage, agricultural drainage, flood routing and water power development are being carried on for purposes of development of engineering science and to contribute toward better teaching of undergraduate and graduate courses in the hydraulic field of Civil Engineering.



Model of Illinois Highway 460 bridge over Wabash River flood plain, built to study eddy which threatened to drop the bridge into a 40-ft. deep hole.

Research in Sanitary Engineering

"The Thing" in the well-known popular ditty was a box containing a valuable substance or article which nobody wanted, which was a hazard to its possessor, and which he could neither dispose of nor destroy. Undoubtedly "The Thing" was radioactive material. We all share possession of "The Thing," it is becoming more and more extensively used in medicine, in the arts, and in industry, and we are now faced with the problem of disposing of it after use. The Atomic Energy Commission is devoting attention to this problem, studies being made at Oak Ridge, Los Alamos, New Mexico, and other places under the immediate control of the A.E.C. and at the engineering experiment stations of various universities.

The University of Illinois has been assigned the project of studying the effect of radioactive materials on the septic (anaerobic) digestion of sludge and the degree of concentration of radioactivity by sludge digestion. Radioactivity is indestructible other than through the ultimate exhaustion of fissionable elements. Some substances become essentially exhausted in a fraction of a second. Others may endure for a century or more. The disposal of such long-life substances in sewers creates the problem being studied here.

The Sanitary Engineering Laboratory is equipped for such studies since it is conveniently located to draw its supply of sewage from the main outfall sewer of the Urbana-Champaign Sanitary District. Tanks are provided for the accumulation of sludge and the laboratory equipment includes a room held constantly at a temperature of 92° F. in which the digesters are housed. Chemical and biological laboratories are available for routine tests and a special shielded laboratory and a special counting room are provided for the handling of the radioactive materials by the personnel trained for this purpose.

Water for troops in the field is a military problem of importance upon which has depended the success of some historic campaigns. The filtration of water by conventional rapid sand filters requires the establishment of permanent installations which cannot be moved and involve serious problems for the transportation of chemicals required in operation. During World War II a filter was developed and used in the Japanese, German, English, and Americon armies which was relatively mobile in the sizes required by troops in the field, and was advantageous in fixed locations because of the relatively small amout of material to be trnsported. This filter, known as the diatomite water filter, has been under investigation in the Sanitary Engineering Laboratory for more than five years under a cooperative contract with the Engineer Research and Development Laboratory of the U.S. Army at Fort Belvoir, Virginia. During this period the efficiency of operation and the equipment to be used have been improved. Studies at present are being directed toward an improvement of the treatment of water before passing it on to the filters. The polluted water from the Boneyard has provided a most desirable source of water on which to test the filters. The wide and rapid variation in quality of this flashy stream puts an excessive stress on the test filters beyond the limits to be expected normally in the field.

Copper tubing for wastes pipes in household plumbing may result in reduced construction costs provided the useful life of the copper in contact with sewage will equal or exceed that of the

commonly used cast-iron pipe. A joint study in cooperation with the Copper and Brass Research Association has been in progress for seven years and is now approaching a conclusion. Three copper tube soil stocks and one vent pipe have been set up in the Laboratory through which sewage from the local outfall sewer has been pumped under controlled conditions for the period of the investigation. Corrosion has been measured by observing loss of weight of the pipes; increase in electrical resistance; and measurement and observation of pitting and incrustation.

Problems in plumbing involve questions of hydraulics and pneumatics that are solved today by trial and error and practical experience. Such solutions are successful but that they are also economical is open to doubt. Tests to answer some of these questions were conducted for a year under a cooperative agreement with the Federal Housing and Home Finance Agency. Although no active research in this field is now in progress, the equipment, equal to the complete plumbing for a three-story residence, is still in place in the Laboratory, together with much supplemental apparatus and equipment in anticipation of a resumption of the studies in the near future.

How to build a household septic tank is a question frequently asked by correspondents with the Engineering Experiment Station. In order to answer this question more intelligently a cooperative agreement for the study of metal tanks was entered into with the American Rolling Mills in Ohio. The contract was completed in 1951 and a bulletin based on these studies is in preparation by the Engineering Experiment Station. Five of the six septic tanks studied are in place under the lawn alongside of the Sanitary Engineering Laboratory, ready for an extension of the studies at any time.

Soil Mechanics

Soil mechanics is a relatively new branch of civil engineering. Only in the last 30 years has science provided methods for determining the physical properties of soils and other foundation materials, for computing the settlement of structures, or for estimating the degree of stability of natural slopes, embankments, or earth dams.

At present, the most important research in this field is the evaluation of the reliability of the scientific methods when applied to actual conditions, and the development of techniques for the application of scientific principles to the practical work the engineer must accomplish. Hence, research in soil mechanics at the University of Illinois emphasizes field observations of the actual behavior of foundations, slopes, tunnels and earth dams during and after construction. The results of the observations are correlated with predictions based on theory and laboratory tests.

One research project, in cooperation with the Association of American Railroads, studies the causes and cures of unstable railroad subgrades throughout the United States and Canada.

A second project deals with the movements of retaining walls and abutments on clay soils. In connection with the Illinois Division of Highways, systematic measurements of movements and soil tests are made on all suitable new bridge construction in the state, and methods are being developed for better design.

Particular attention is given to methods of designing foundations for industrial structures, large and small. Studies of the foundation problems unique for each locality with a different geological setting are being made and assembled into a sort of foundation atlas for the United States. This is a long-range project that will require many years.

Hope is a better traveling companion that fear.

* * *

If the family budget is in the red, no doubt it is something you ate.

—*Pathfinder*

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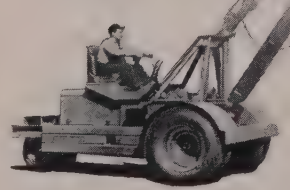

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How to lick dust, moisture and acid fog

prevalent in the atmosphere surrounding the Rumford, Me., mill of the Oxford Paper Company posed a problem in power circuit maintenance. The combination of these elements caused wooden structures and even over-voltage insulators to become conducting, resulting in phase-to-phase flashovers and burndowns when ordinary overhead wires were used.

The solution of this serious problem was found by substituting Okolite-Okoprene Self-Supporting Aerial Cable for the open wires. According to company officials, the combination of Okolite high voltage moisture and heat resisting insulation, protected by non-conducting weather and chemical resistant Okoprene sheathing, has eliminated this trouble.

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Steps forward in . . .

Agricultural Engineering

by Howard Hadler, Ag. E., '54

The Agricultural Engineering Department at the University of Illinois carries on an extensive research program in order to develop new farm equipment and farm practices and to improve existing equipment and practices. The research program covers such a scope as to allow several members of the staff to devote full time to it. Also the agricultural engineering research program is characterized by extensive cooperation with other agencies. At the present time three industrial or commercial organizations contribute to full-time projects. The Aluminum Company of America contributes to a research study for the purpose of determining the ways in which aluminum can be used in farm structures and building equipment. The Illinois Agricultural Association, and Country Mutual Fire Insurance Company sponsors a project aimed to find and eliminate the hazards that cause fire and wind losses. The Public Service Company of Northern Illinois and its affiliates sponsor studies in the applications of electricity for farm operations. Along with these companies many others provide aid for agricultural engineering research projects.

At the end of World War II, the capacity for productiion of aluminum led to the search for new uses. The qualities of light weight, resistance to corrosion, relatively high strength, and workability, together with the potential supply gave indications that aluminum might be widely used.

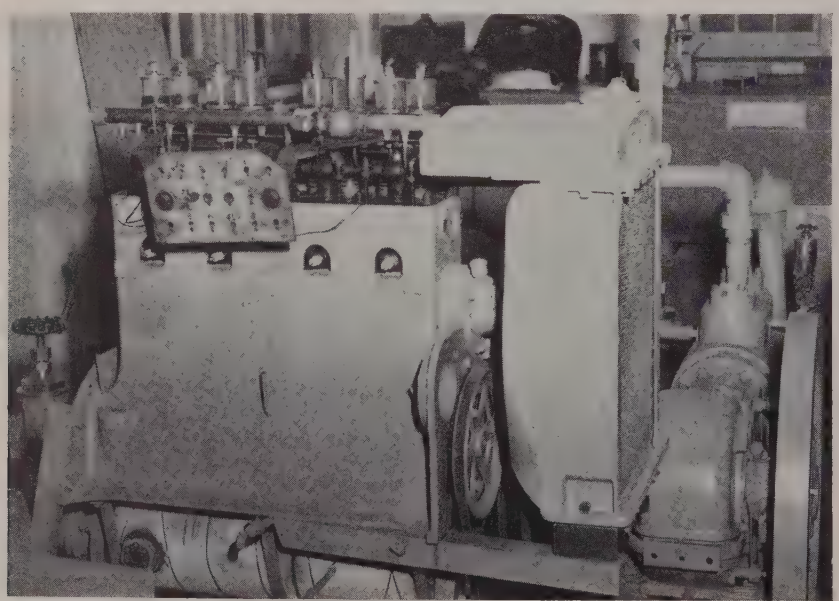
On the other hand, aluminum was not resistant to corrosion under certain conditions, little was known as to requirements of gages, shapes, and methods of application for farm uses. Prevailing building plans had not been prepared with aluminum in mind. The research programs in conjunction with the Aluminum Company of America have been carried on to develop new building planes, to study the application of sheet materials, analyze the results of using aluminum for a variety of purposes — gates, windows, dairy stalls, poultry equipment, and other devices; and to study such problems as nailing, handling, reflective qualities, durability in paints, and possible deficiencies under various conditions.

The principle work under this project includes: (1) Construction of an experimental poultry house, and accumulation of data, (2) Use of aluminum foil, reflective insulation and sheets, (3) Study of methods of application for sheets of various thicknesses, (4) Tests of aluminum devices and equipment in use, and (5) Development of building plans for best utilization of aluminum sheets.

In another project, sponsored by the Illinois Agricultural Association, and Country Mutual Fire Insurance Company, it is found that in the final analysis, the safeguards against loss not only reduce the cost of insurance, but prevent inconvenience, damage, injury, and possible loss of life. Evidence gathered from various sources reveals that a few major preventative measures may reduce losses by millions of dollars. For example, safe wiring, safe flues, lightning protection, and recommended practices in the installation and use of heating systems and fuels might prevent a majority of farm fires. Building repair, anchors, bracing, use of suitable materials, and recommended construction methods prevent major windstorm losses.

This research program is directed toward: (1) Analysis of records of loss, (2) Development of methods to offset losses, (3) Assembly of recommendations for loss prevention, (4) Organization of training and demonstration programs (5) Preparation of practical inspection form, and (6) Publication of recommendations.

A project sponsored by the Public Service Company of Northern Illinois and its affiliates is studying the opportunities for greater use of electricity. Illinois farms are more than 90 per cent electrified, but opportunities are present for far greater use of electricity. In the past, electricity has been used for lights, home appliances, cooking and refrigeration, and to a lesser extent for dairy



Part of the experimental equipment used in the research on valve wear. Various lubricants are used to determine their effect on valve wear.

work, feed grinding and miscellaneous jobs.

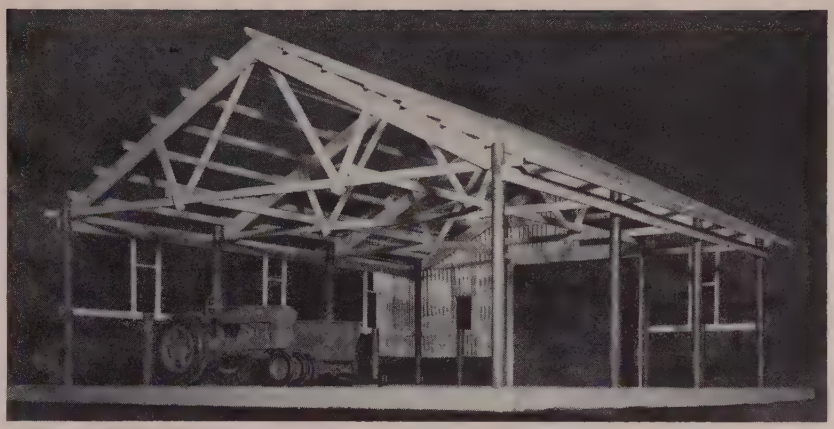
The future expansion of electric service depends largely on the development of automatic processes, new devices, and machines for work at the farmstead, and on new methods of operation. Electricity can serve especially well in the field of processing for such purposes and feed grinding and mixing, feed and silage handling, crop drying, and refrigeration. Electric power is needed for operating feed distributors, ventilating fans, barn cleaners, and heater controls. Heat lamps, tank heaters, animal and chick brooders, and heating cable are examples of electrical applications that need study.

The present work on electric application is centered on two major studies, with much more to be done later: automatic feed handling, grinding, mixing, and distribution; and control of environment by ventilation and supplemental heat.

Since 1948 three cooperating organizations have been active in the development of automatic feed-handling equipment at the Illinois Agricultural Experiment Station, Urbana, Illinois: (1) the Public Service Company of Northern Illinois; (2) the Agricultural Engineering Department, University of Illinois; and (3) the Farm Electrification Division, U. S. Department of Agriculture. During this period processes and equipment have been developed to move ear corn from a crib or storage bin into an auger-type feeder for a hammermill; blend and mix shelled corn, oats, and concentrates and feed such mixtures into the hammermill; and control the operations of this assembly by an electrical control box.

Another project is the investigation of protective coatings for weathered galvanized sheets. Galvanized metal sheets are extensively used for siding and roofing of farm buildings. Weathering deteriorates the zinc coating on these sheets and exposes the metal sheet to rust action, presenting a common maintenance problem. Protective painting may be used to prevent rusting. However, many considerations are involved, such as determining the proper kind of paint to use, deciding on the proper time to repaint, and finding the best method of application.

In 1932, the American Zinc Institute began conducting tests on the value of various paints as protective coverings for galvanized sheets. Test panels were coated with different paints and the resistance to weathering was noted. In 1948, the records for the sixteen years were turned over to the Department of Agricultural Engineering. By this time test panels covered the entire roof area of six buildings on the farm of Raymond Harwood at Donnellson, Illinois. In all, 91 paints were used in the study, including all coatings that were regarded as suitable for use or which had been commonly used on galvanized metal. The Department of Agricultural Engineering and the Agricultural Experiment Station was to analyze and interpret the records and report conclusions as to the kind, or kinds, of paint to use, how the paint should be applied, and how the paint coatings compared in relative durability under typical farm conditions. Also, in 1948, a new series of tests was begun at the Illinois Agricultural Experiment Station to include a wide range of old and new products in various coatings and combinations. This new series of tests which is now being carried on provides for ample checks, duplications, and uniform exposure conditions. The data which was collected prior to 1948 has been analyzed and interpreted and has been prepared for publication in a bulletin on the "Durability of Paints on Weathered Galvanized Roofing," Bulletin 565 of the University of Illinois Agricultural Experiment Station.



A model of a pole-frame machinery storage building showing the basic construction features.

Much time is being devoted to the study of farm buildings. The Department of Agricultural Engineering cooperates with the Small Homes Council of the University of Illinois and with the North Central Region, comprised of Agricultural Experiment Stations of various colleges and universities in the north-central region of the United States, in its studies of farm buildings. One of the major problems in livestock housing and crop and machine storage is in keeping the housing facilities functional while introducing the necessary changes due to advancement in farm practices. Necessary design changes must be continually developed. Added knowledge and new advancements in construction principles also necessitate a continuing change in design.

Automatic feed-grinding equipment which is being developed and tested by the Department of Agricultural Engineering in cooperation with other agencies.

The research in farm building design comprises many separate projects, the results of which are used to develop new designs and new design and construction principles. As one phase of this research work, a basic farm house plan has been developed which can be altered in innumerable ways to suit the needs of the individual. Another result of the farm housing research is the "flexi-plan" which consists of a basic plan for the living unit with a number of supplemental plans which may be added to the basic plan to provide a one, two, or three-bedroom house, or to provide a different type of room arrangement outside of the basic unit.

Other research is being carried on to improve the arrangement and design of livestock housing units with special emphasis given to the efficient use of farm labor. Also construction principles are being studied to determine various ways of constructing farm buildings with emphasis placed on availability of materials, and practical and economical construction.

Studies are being carried on on tractor valve troubles. In the past operators have been confronted with valve troubles in tractors such as excessive valve wear and valve sticking. The tests on the causes and cures of tractor valve troubles has been going on in the department for some time now and has been recently expanded to include a total number of sixty tractors. This increase was made possible by a contract between the Department of Agricultural Engineering and the Northern Regional Research Laboratory of the U. S. D. A. at Peoria, Illinois. The cause of some of the troubles has been found to be due to lead and gum in the fuels used, lubricating oil quality and engine design. The new studies has been devised to try to find out the relative importance of the various causes and to try out some of the remedies suggested. The division of the tractors in the test is to be made as follows: twenty farm tractors in the Champaign-Urbana area will operate on "white-gasoline" with alcohol-water injection devices to prevent knocking caused by the white gas; twenty tractors with the usual valves and fuels will be used as a check; ten tractors will be equipped with exhaust valve rotators along with ten others which already are running under test conditions. Along with these, a test unit has been set up in the research laboratory to determine the value of various lubricants in preventing valve wear and the extent of valve damage incurred during the use of these lubricants.

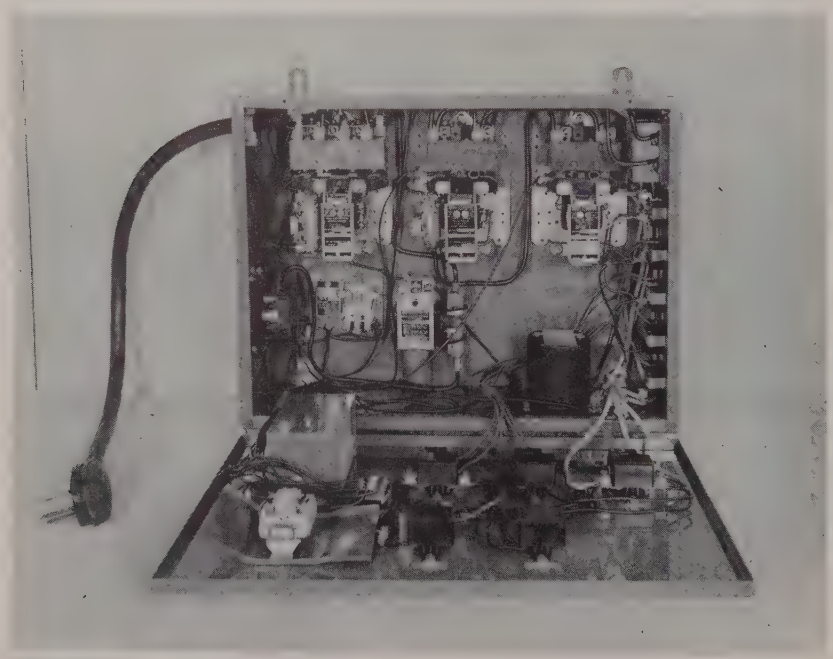
Experiments are being conducted to determine maximum efficiency of corn pickers. It is known that unless a corn picker is properly adjusted, much waste and loss of grain occurs. Some of the factors under consideration in this study are: proper setting of the snapping rolls from the ground; speed of the machine thru the field; and setting of the husking rolls along with other things. Another feature of this experiment is the application of the combine to the harvesting of corn. The combine is fitted with the cylinder and concave system as ordinarily except that the cylinder can be set at various angles, has a variable speed control on the cylinder, and there are six additional rasp bars on the cylinder to do a more complete job of cleaning the corn. Studies on this arrangement so far have shown a loss of only 1% of kernel corn and a loss of 4% due to damaged kernels. The chief hindrance to this project is the shortness of the season in the field and, therefore, the short amount of time that practical experimental work in the field can be done.

A project is also being carried on with connection to runoff from agricultural watersheds. Runoff rates and other data is being gathered on a portion of the Robert Allerton Estate near Monticello, Illinois. This data, along with other data on slope, vegetation and other factors can be used to develop soil-conserving practices.

One of the most important developments in the agricultural engineering research program has been the construction of the Agricultural Engineering Research Laboratory, which was completed in 1952. Before that time, the increased research program, along with other space needs, had resulted in crowding all phases of the department's program. The new laboratory, therefore, provided a much needed facility for the research work in the department. The building is single story of brick and concrete block construction with flat roof. Nearly 9,000 square feet of work space are provided by the building. The building provides for the needs of the research programs in structures, rural electrification, soil and water engineering, power and machinery and crop processing.

Along with the research facilities provided by the Agricultural Engineering Building and the Agricultural Engineering Research Laboratory, the Department of Agricultural Engineering operates a 40-acre farm on the University of Illinois farms at Urbana, Illinois and carries on experiments at the Robert Allerton Estate and the Dixon Springs Experiment Station. Also, many phases of the experimental work is carried on on various farms throughout the state of Illinois.

Besides the experimental work mentioned previously in the article, many other experiments are being carried on, which range from long-time studies of improvement in tillage practices, rust preventatives, and soil conservation methods, to graduate studies on limited projects. The results of the experimental work in the department is reported in bulletins and circulars of the University of Illinois Agricultural Experiment Station, and in articles in the Journal of Agricultural Engineering.



An electrical control unit developed by the department and used with the automatic feed-grinding equipment. In the picture it is opened for inspection.

METAL CUTTING RESEARCH

by Eric Aagaard, M.E., '53

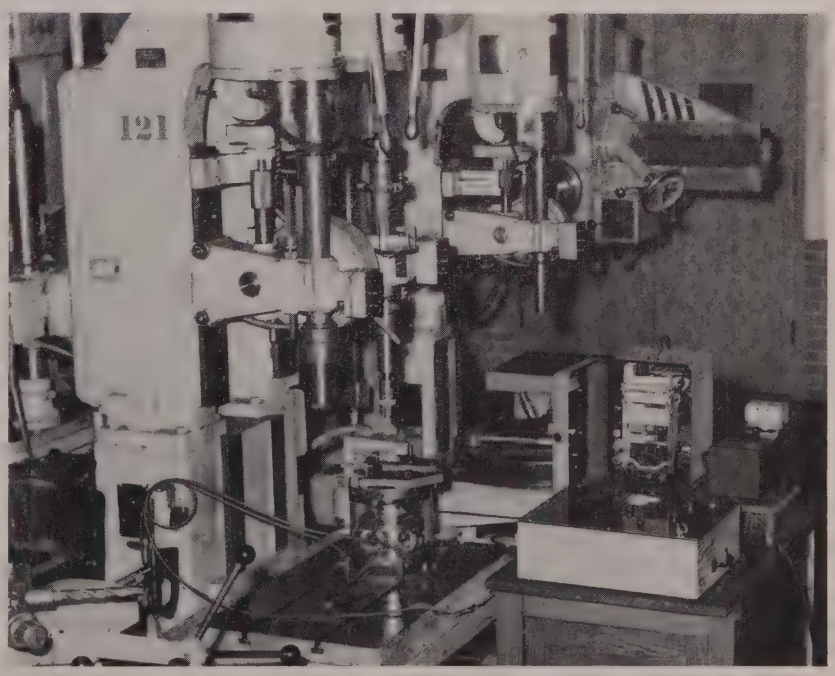
One of the many experimental investigations being carried on at the University of Illinois involves a long term study of the basic processes of metal cutting, by Prof. K. J. Trigger, Prof. B. T. Chao, Mr. B. F. Turkovich, and others of the department of mechanical engineering. Many of the problems in metal cutting involve obtaining maximum cutting speeds and efficiencies together with long tool life. Toward solving the problems, interesting test setups have been developed at the University of Illinois to study the variables involved, and to varify analytical evaluations of the problems.

Although most of the experimental work is being done on an ordinary 16x54-inch metal cutting lathe, the results obtained are equally applicable to other machines using similar cutting tools such as shapers, planers, milling machines, boring mills, etc. The tool-chip interface temperature has long been recognized as a limiting factor in metal cutting, because excessive temperatures will reduce tool hardness and life. The term, tool-chip interface, is used in preference to the term, tool-workpiece interface; because the area of mutual contact is between the tool and the chip coming off the workpiece, not between the tool and the workpiece. Temperatures are measured by using the tool-chip interface as the hot junction of a thermocouple circuit. It would be well to review some basic knowledge of thermoelectricity, before a further discussion of the Herbert-Gottwein tool-work thermocouple is made.

At a junction of two dissimilar metals an electric potential will be produced which varies in a direct relation with the temperature of the junction. A continuous electrical circuit made of two wires, one composed of each dissimilar metal, will contain two junctions of the dissimilar metals. The total electromotive force produced in the circuit will be the algebraic difference of the potentials produced at each junction. A current will flow in the circuit when one junction is held at a higher temperature than the second. These junctions are called the hot and the cold junctions according to their relative temperatures.

A thermoelectric circuit may be cut at any point and a wire of any conducting material may be introduced in the circuit without altering the electromotive force produced, providing that the two new junctions are kept at a common temperature. This law of intermediate metals allows the insertion of a potentiometer to measure the electromotive force produced by the difference in potential of the hot and cold junctions. In the usual circuit the hot junction is at the unknown temperature to be measured, while the cold junction is at the reference temperature. The circuit is usually separated at the reference junction for the insertion of the leads to the potentiometer, care being taken that both parts of the separated junction are at the same temperature.

The cutting tools used in these investigations are of a conventional design with inserted cemented carbide cutting edges. The carbide edge, together with the chip coming off the workpiece, serves as the hot junction of the thermoelectric circuit. Through a hole drilled in the shank of the tool, a carbide rod is placed in contact with the insert, but insulated from the shank. The carbide rod must be of the same chemical com-



Drill press equipped to measure torque developed in tapping metals.

position as the cutting edge, otherwise a potential will exist at the point of contact between the two. The entire tool is insulated from the rest of the lathe. The free end of the carbide tool protruding from the end of the tool is connected by an iron lead wire to one terminal of a potentiometer.

An iron lead from the other terminal of the potentiometer is connected to a brush in contact with the rotating workpiece. This brush, insulated from the frame of the lathe, is made from a section of the workpiece. By applying the law of intermediate metals, it becomes evident that the reference junction is merely the connections of the potentiometer lead wires with the carbide tool and with the brush. Both these connections must be at the same room temperature. Calibration of a thermocouple made from the same carbide and steel as used in the tool and in the workpiece is done in an electric furnace using a standard chromel-alumel thermocouple to obtain the actual temperatures.

The potential produced by the tool-work thermocouple might be affected by several factors, the effect of chip flow on the tool face, the effect of chip deformation, and the effect of tool-wear due to the rubbing of steel on carbide. Various test setups were built to show that these factors had a negligible effect on the potential developed by the thermocouple. A discussion of these tests, together with a more complete description of the tool-work thermocouple, may be found in the Transactions of the American Society of Mechanical Engineers for February, 1954.

The results of the numerous tests are too voluminous to be discussed in this article. Much valuable data has been obtained as to the effect on interface temperature of such variables as cutting surface speed, tool feed rate, tool back-rake angle, workpiece hardness, and chip thickness.

For some analytical research it is desirable to know the cutting forces exerted on the tool. A unique dynamometer designed and constructed in the department of mechanical engineering at the University of Illinois measures the vertical and horizontal components of the cutting force. When mounted on the tool lathe, the horizontal component of the force is parallel to the axis of the workpiece. The vertical component is tangential to the rotating surface of the workpiece. The cutting tool is mounted in a holder at the end of a short, stiff cantilever arm of rectangular cross-section having approximately sixteen inch deflection under a vertical load of one pound. The minute deflections caused by the components of the force are measured by two electric gage heads, one each mounted to act in the vertical and horizontal directions. The operation of the electric gage head involves the unbalancing of a resistance bridge circuit by changes in the air gap of an iron core reactor as produced by the deflecting cantilever. The tool holder was designed so that both components of the cutting force act approximately through the longitudinal neutral axis of the cantilever. Thus the arm will deflect only in the direction of the force acting upon it. The device is calibrated with dead weights. Using the results of such dynamometer tests, an analytical determination of interface temperature may be developed based on the theory of metal cutting. The calculated values of interface temperature thus obtained are in fair agreement with those determined with the tool-work thermocouple.

Part of the current work in the tool cutting research program involves a study of tool wear caused by abrasion of metal from the workpiece onto the carbide insert on the cutting tool. This build-up on the tool will be detected using an X-ray technique.

Another current investigation involves a study of the unique development in metal cutting. The forces developed by the tool cause strain in the specially designed miniature cutter inside the workpiece. Wire strain gauges each consisting of a network of five wire arms firmly cemented to the cutter. Changes in the electrical resistance of the network, caused by strain in the cutter, are measured with a resistance strain bridge circuit. Since the strain produced in the cutting depends on the forces exerted by the tool, calibrated wire strain gauges provide a simple method of measuring these forces.

Measurement of metal cutting force with a toolholder dynamometer. Photos by Bob Feldman

---

The old joker perked up on a rotating hair on the mill bridge.

"Sixty-five cents," said the bridge-keeper.

"Sold!" cried the joker.

* * *

Fine mathematics Jack, you are only paying thirteen and milk. Are you on a diet?

Second: No commission.

* * *

"You're a pissing man with both feet on the ground, sir." What do you do for a living?

I take orders from the guy with both feet on the desk."

* * *

However: Mable, what happened to the canary?

Mable: I don't recognize them. It was there when I cleaned out the cage with the vacuum cleaner.

* * *

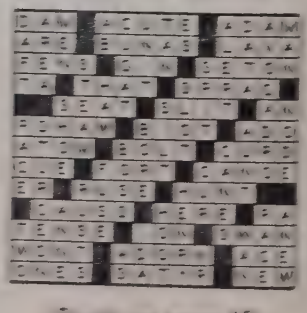
Prospective tenant: But why do they make these apartments so small?

Agent: That's so the tenants will have no room for complaint.

* * *

Mixed metaphor is a common expression—but no one ever hears the departing guest say "I'll be back soon."

Crossword Answer



Puzzle on page 60

The New Norton G Bond. The grinding wheel this man is using — in a Norton grinding machine — is made with the new Norton G Bond, one of the most important grinding wheel achievements in 40 years. The G Bond is a special vitrified bond, developed by Norton research engineers, that gives greatly improved grinding performance in many precision and semi-precision jobs — typical of the "Touch of Gold" that Norton brings to all grinding.

Striving To Produce The G Bond. Roberto C. Lanzy, M. S., Ch.E., a recent graduate of Worcester Polytechnic Institute, examines bond particles under a stereoscopic microscope in the Norton research laboratories.

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Scenes from . .

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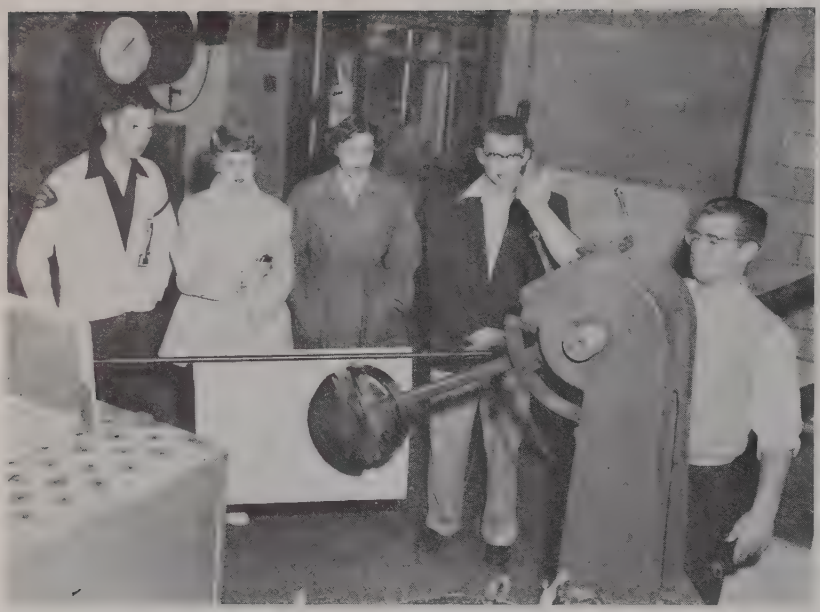

Above: Testing of metals with a Charpy impact machine in the Metallurgy Laboratory. Below: An interesting exhibit in the M. E. Laboratory of the effects of air conditioning on the human body.

In a typical demonstrat
Open House a student e
automobile ignition syste

Photos b

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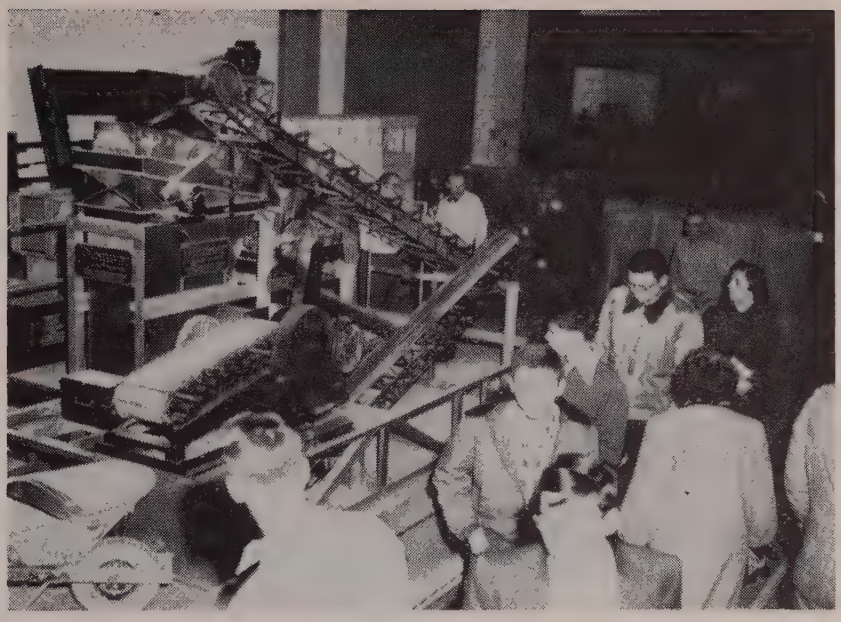
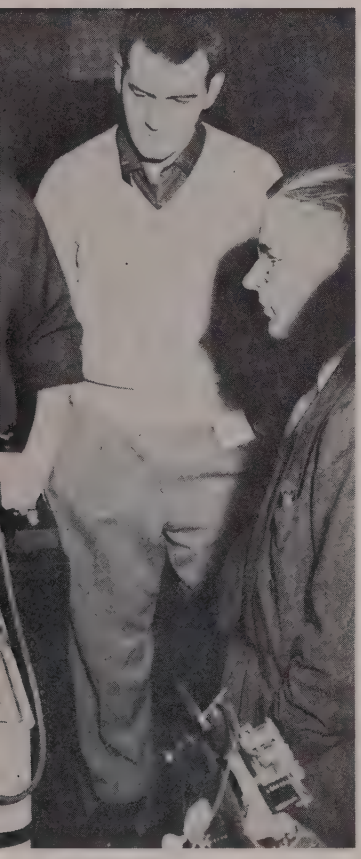
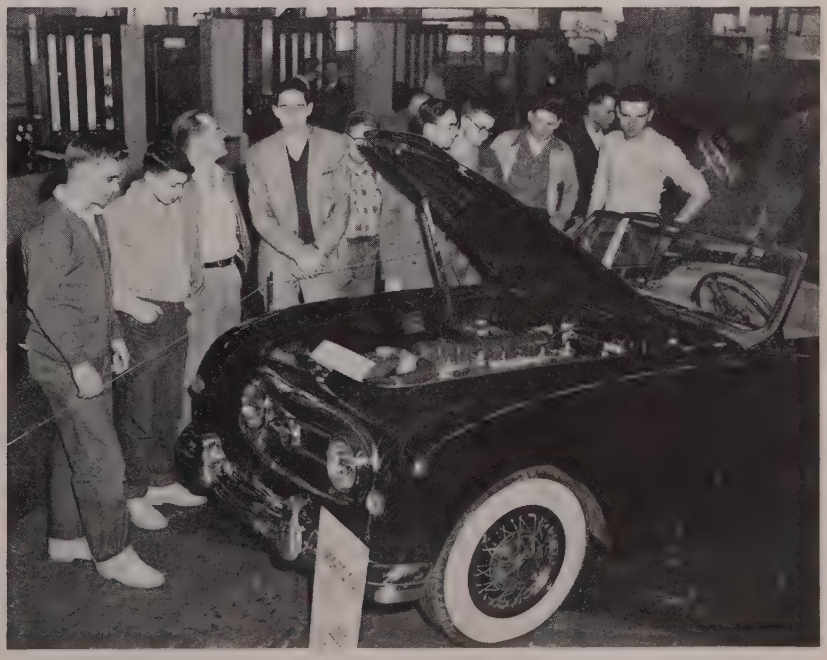




Above: Visitors view a model rock crushing plant set up in the materials testing laboratory. Below: The sport car on display in the Internal Combustion laboratory of the M. E. Department was one of the many attractions of the Engineering Open House.



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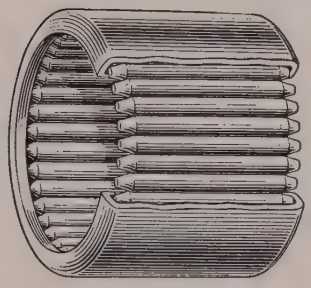
The Torrington Needle Bearing

. . . shaft hardness determines effective load capacity



The economy of the Torrington Needle Bearing is due in part to the fact that the shaft usually serves as the inner race. Thus, since the shaft is an integral part of the bearing, its load capacity limits the capacity of the bearing assembly. In order to obtain the full rated load capacity of the Needle Bearing, it is necessary that the shaft be at least surface-hardened to the equivalent of Rockwell C-58.

Loads and Speeds Related to Shaft Hardness

Because of material or design limitations, it is sometimes desired to run Needle Bearings on shafts softer than the recommended Rockwell C-58. This can be done safely providing the bearing loads and speeds are not too severe. However, the capacity of the bearing assembly is only as great as the load capacity of the shaft, regardless of the rated load capacity of the bearing as indicated in the catalog. The shaft capacity decreases very rapidly as the surface hardness is reduced below the recommended Rockwell C-58 minimum hardness.

Figure 1 shows this very clearly. It can be seen that reducing the shaft hardness to Rockwell C-52 gives a resulting load factor of .5. In this case, the catalog rating must be multiplied by .5 in order to obtain the true capacity of the bearing assembly.

Unheat-treated, cold rolled shafting will only carry 2%-3% of the bearing's rated load capacity.

The speed of the application is also important in determining proper hardness to assure satisfactory shaft life. The chart in Figure 2 illustrates this effect.

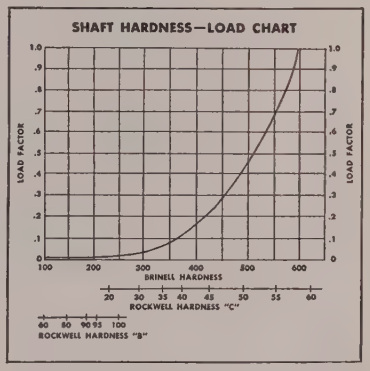


Figure 1. If the surface hardness of the shaft, its tensile strength, or the per cent of carbon is known, the load factor can be read either right or left from the intersection of the curve. The load factor, multiplied by the rated capacity of the bearing, will give the shaft capacity and the capacity of the application.

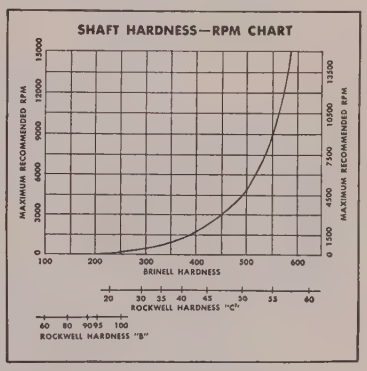


Figure 2. As the speed increases, it is desirable to increase the shaft hardness. For a given rpm, read across to the curve and down to the proper hardness. Conversely, if hardness is known, read up to the curve and across to the maximum rpm for that shaft.

Hardened Inner Races Available

When it is either impossible or impractical to harden the shaft, it is necessary to use an inner race which will provide the required surface for Needle Bearing operation. Inner races are available for all sizes of Needle Bearings. When used, inner races should be securely fastened to the shaft by clamping against a shoulder, by snap ring, or by press fit.

When designing Needle Bearings into a piece of equipment where shaft hardness is a question, the economics of using inner races as compared to a properly heat treated shaft should be carefully analyzed. When all factors such as inner race cost, securing devices, and actual assembly time are considered, it is usually found more economical to heat treat the shaft.

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Flying Ahead with . . .

Aeronautical Engineering

by Maurice Garnholz, Aero. E., '56

Since the organization of the Aeronautical Engineering Department at the University of Illinois in 1944, research has formed an integral part in the activities of both the students and the staff. Most of the staff members divide their time between teaching classes and delving into research in their respective specialties. Many papers written by several members of the staff have been published widely, both here and abroad.

A special problems course and chances to be employed as a computer or draftsman on a major research project are the two major opportunities for research open to the undergraduate. Graduate students with satisfactory qualifications may receive appointments as research assistants or associates, and all graduate students are required to conduct some independent research and submit a thesis.

A research project labeled as the Supersonic Propeller Problem was begun in June, 1947, and finished in March, 1949. Directed by Professor H. S. Stillwell, head of the Department, and completed through the efforts of four staff members, the object of the investigation was the development of a mathematical method for the design and analysis of propellers operating above the speed of sound.

Dr. T. P. Torda accepted a contract from Aerojet Engineering Corporation in 1950. Entitled "Boundary Layer Control by Continuous Surface Suction or Injection," the object of the analysis was to investigate the possibility of stall-prevention and achievement of high lift airfoils.

At the present time the department is involved in research in several specific areas. Dr. Harry H. Hilton, in one area of research, is concerned with photoelastic equipment. The design of a transonic wind tunnel is handled largely by Lloyd Gross, with Professor Stillwell in charge of the whole project. Lowell Eldrenkamp and Jim Xerikos, working under Professor T. P. Torda, have charge of research in mixing processes, done in connection with the Bentonite Channel. Dr. Fletcher handles research with the shock tube. Fred Hall, whose work is also supervised by Professor Torda, is conducting investigations of a compressor. Mr. P. Born, Research Associate, is also working on the same project. Professor McCloy is dealing with research in the field of propulsion.

Unlike several of the aforementioned projects, which are purely theoretical and mathematical, that dealing with the transonic-supersonic wind tunnel, conducted by Lloyd Gross, has tangible portions. Although much of it is still on paper, a tunnel is being built at the University of Illinois Airport. The test section, where a model will be placed, is to be 4″ x 6″. The complete apparatus will be 15½′ long, with the widest part being only 32″. Two Allison V-17 twin-jet engines, driving centrifugal compressors, will pump air through the tunnel at a rate of 10½ pounds mass per second.

In scientific circles, for purposes of simplification, the speed of sound is designated as Mach number 1. Hence, a speed of 0 miles per hour is Mach 0. As an object approaches the speed of sound the Mach number approaches 1. When the speed of sound is passed the Mach number becomes greater than 1, e.g., Mach 1.5 would indicate a speed 1½ times as great as the speed of sound, or about 1140 m.p.h. (760 x 1.5), at a temperature of 10°C.

It is possible to build a wind tunnel with as high a Mach number as is desired. Wind velocities in the wind tunnel at Aero Lab A start from rest and go to 150 m.p.h. Used as a student instruction tunnel, it is used to verify the theory of subsonic aerodynamics. A sufficiently large wind tunnel can get the air up to a speed of Mach .85 easily, but at higher speeds the shock wave which forms bounces off the wall and hits the model a second time, which causes unwanted additional interference. Enormous amounts of air can be pushed through until the speed of sound (Mach 1) is reached. After Mach 1 a strange phenomenon occurs. When the air is expanded (allowed to proceed into a larger section of the tunnel) the velocity *increases!* And similarly as the tunnel becomes smaller the air travels slower. This occurence is just the opposite of what happens at subsonic speeds.

Even with this occuring, it is still easy to put air through at a speed of Mach 1. But just as soon as something (usually a model) is put in the tunnel, immediate trouble arises. The shock waves formed on the object (particularly the wing) bounce off the walls back to the wing, setting up double shock waves.

Gross and his assistants believe that they have a solution to the problem. They intend to draw the air off through holes to prevent this "choking." Since the bouncing shock waves of air bounce off the wing and out they cannot reinterfere with following shockwaves. But first the research workers intend to run tests to see which type of holes will be best for this work.

Tunnels have been built in other sections of the country which can handle air with speeds up to Mach .9, while other, larger tunnels have been built handling air with speeds above Mach 1.3. The University wind tunnel is intended for research on air speeds from Mach. 9 to Mach 1.3. It is as Lloyd Gross says, "That little gap needs to be bridged," before information about the supersonic can be considered complete.

As in almost any field of research and experiment, one small, unforeseen thing may alter things greatly.

It is expected that the wind tunnel will be finished about the 15th of April.

There are two ways to go about solving any problem—direct and indirect. In the case of the blade for a compressor, the direct method would entail the

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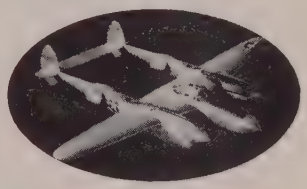
This Plane made History



The P-38 Lightning – first 400 mile per hour fighter-interceptor, the "fork-tailed Devil" that helped win World War II.

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The Super Constellation – larger, faster, more powerful; the plane that bridges the gap between modern air transport and commercial jet transport.

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specifying of the blade shape, then the solving for the flow around it. The blades interfere with the flow though, and hence it is practically impossible to solve this problem directly. It is just this type of research that is being done by Fred Hall.

In the indirect method, one would specify the velocity components and solve for the blade shape that would be best. With this method one doesn't have to compute the flow effects. The department is, consequently, using the indirect method in the analysis of a compressor, which is not yet built and probably won't be built unless the equations turn up something great, for this is one of the research projects which is all paper work and theory. All analytical work now, this paper research is intended to lead to an optimum in pressure design.

To acquire an ideal blade a mathematical analysis is necessary. The results of this analysis will be used in the design of compressors, which will be used in jet engines, cooling, and electronics. The results would also apply to turbines, for a turbine is essentially a compressor in reverse.

Research delving into the flow of streams past a flat thin plate, two plates, or even a tube is being carried on by Lowell Eldrenkamp and Jim Xerikos. "Theoretical Studies of the Mixing Process of a Jet Impinging into a Stream of Large Mass" is the imposing title of this project. It is a comprehensive study of the things that happen in the wake.

Located in the basement of the Mechanical Engineering Building is a piece of equipment used in connection with this phase of research carried on by the Aeronautical Department. This piece is known as the Bentonite Channel, and the method used in experimental work is the "Photo-Viscous Method for Analyzing Fluid Flow." This method uses polarized light for visualizing certain areas in a field of moving liquid, which is a colloidial suspension of bentonite clay in water. This solution flows through a tube about 15 feet long with cross-sectional dimensions of approximately 1″ x 6″. When the suspension flows, a pattern appears around the model due to double refraction induced in the suspension by the presence of velocity gradients in the flow. This pattern is composed of fringes of various colors. These fringes represent different amounts of double refraction in the fluid, which in turn represent different values of the velocity gradients.

This method is applied to qualitative studies of laminar and turbulent conditions in the wake of the flat plate. All aerodynamics is built around a flat plate. From a flat plate it progresses to a curved plate and finally to a curved plate with thickness (a wing).

In the Bentonite Channel a flat plate is held in a plastic rectangular tube. Plastic material is used because of its transparency. Also the bentonite clay has properties that corrodes ferrous metals.

In previous investigations, the velocity distribution of the mixing streams has been assumed as uniform at the start of mixing, and, thus, the influence of the existing boundary layers along the separating plate has been neglected. It is believed that the results show, for the first time, the influence of the upstream boundary layers on the mixing process.

The width of mixing regions and the velocity distribution in it has been evaluated by the von Kármán integral concept as applied to the momentum and energy equations.

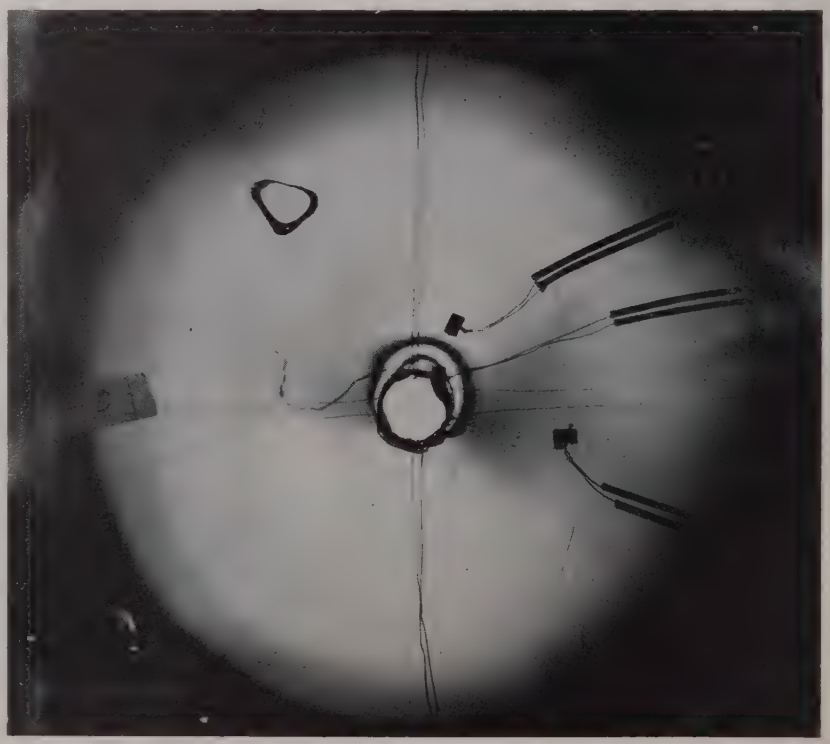
The University of Illinois is the first place where any work has been done on mixing processes around a plate, taking into account the fact that the velocity distribution isn't uniform due to the boundary layer.

There are several theoretical problems involving the behavior of shock waves when they are reflected from walls and other obstacles which have not yet been satisfactorily solved. These are fundamental problems in the behavior of shock waves and are best studied experimentally. The problem of the behavior of shock waves is a basic one in the aerodynamics of compressible fluids.

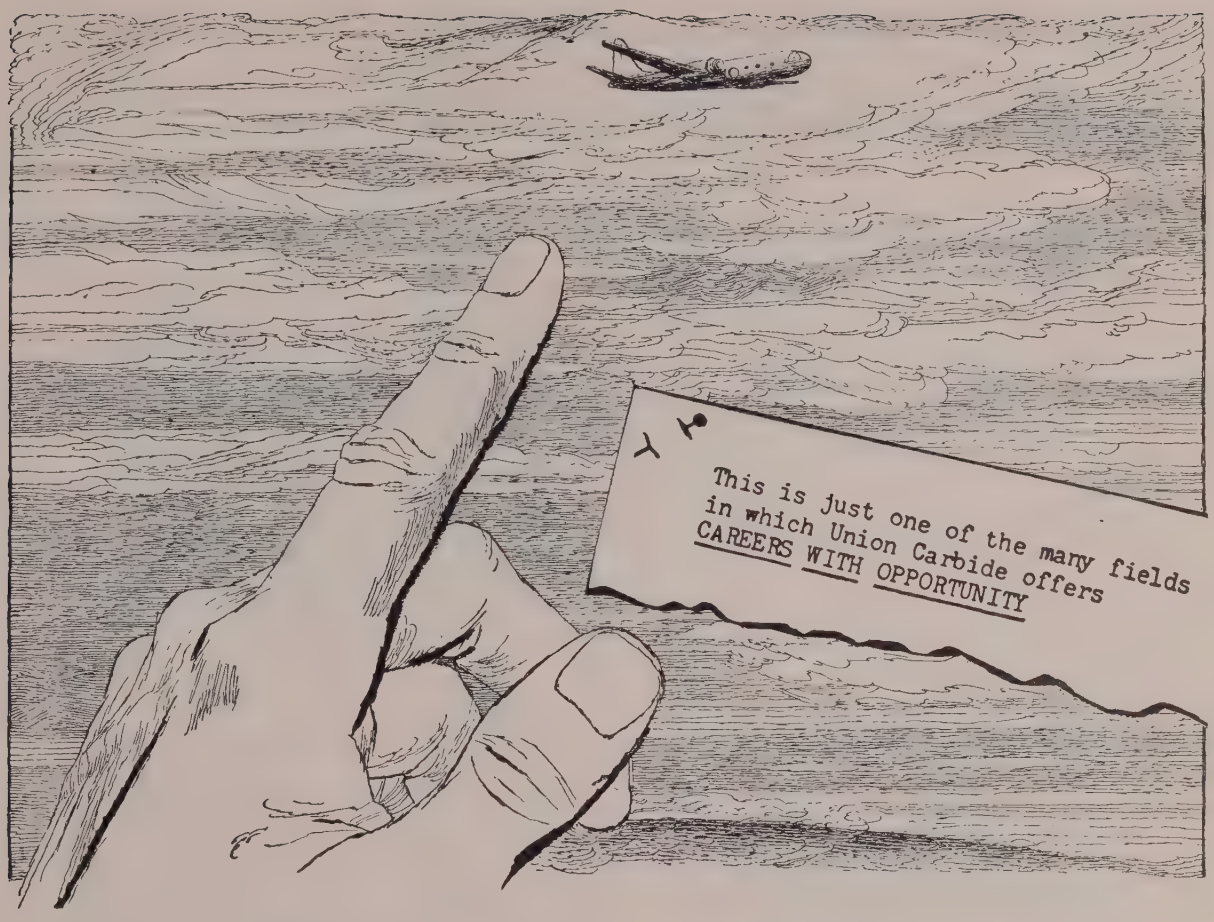
The instrument used to carry on this type of research is the shock tube, located in Aero Lab B and operated under the direction of Dr. Fletcher. It has a cross section of 4″ x 15″ and is 36 feet long. The shock tube permits the study of air flow and pressure about a body at supersonic speeds.

At the same time a shock wave is generated, a flow of air is generated behind it. This flow has a speed which depends upon the strength of the shock wave and can be controlled from Mach number 0 to Mach 1.7. This includes the so-called transonic range, in which conventional wind tunnels are difficult to use. Wind of transonic speed is used so that investigation can be made either of the behavior of the shock or of the flow which follows it when a model is placed in the tube.

A shock wave is generated in the U of I shock tube by first putting a diaphragm of plastic—sometimes paper—in a special place near the beginning of the tube. A pressure of 600 lbs. / sq. in. is applied by eight cylinders, each 2″ in diameter. Diaphragms, usually made from cellulose acetate, with a thickness of 3, 5, 7, 10, or 15 thousandths of an inch are used. The diaphragm is clamped in and is compressed



Thermal stresses showing around the hole of a plastic body which is being heated by electricity. The three large wires are thermal couples.



Things are different—up there!

You would be amazed at the tricks nature plays in the stratosphere

As aviation progress has carried man farther into the upper air, he has found that nature has many tricks up her sleeve in the stratosphere. Many things that worked well on the ground wouldn't do as well, or failed completely, in the space beyond the clouds. Things are truly different up there.

CARBON BRUSHES ARE AN EXAMPLE—These brushes are the contact points that carry electricity between moving and stationary parts of motors and generators. They're in electric razors, sewing machines, huge diesel locomotives—and in modern aircraft.

THEY COULDN'T STAND ALTITUDE—Today's high-flying planes require literally hundreds of small electric motors and many carbon brushes. Here was one of nature's quirks, for brushes which worked well on the ground and at lower altitudes couldn't take the thin, dry air of the stratosphere. They'd spark and quickly disintegrate. And if the brushes failed, the motors also would fail.

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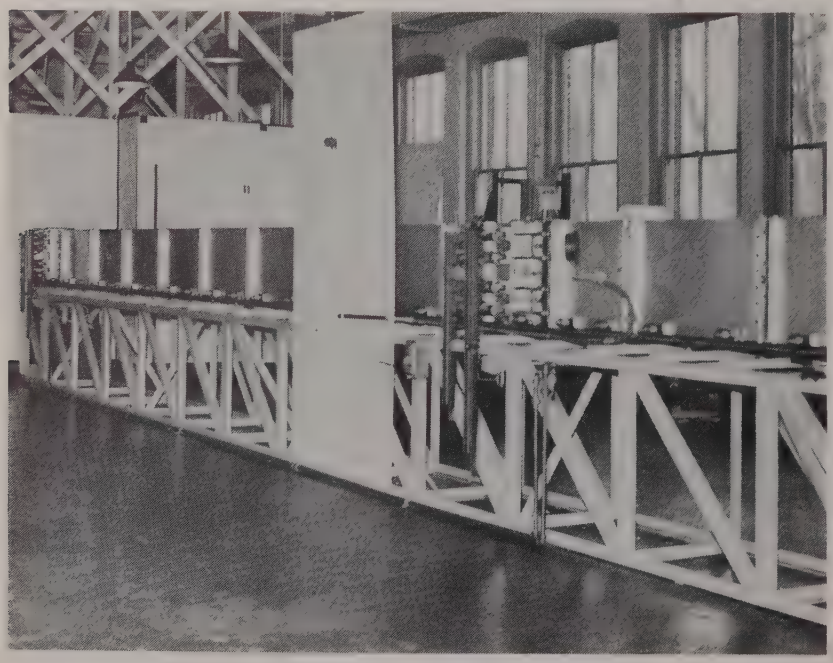
in the high pressure side (shorter end). Then the diaphragm is broken with compressed air or punctured with a needle made for this purpose. This compressed gas escapes down the tube, pushing low pressure gas ahead of it and generating shock waves *in* the *low pressure* gas.

As the air is compressed at transonic or supersonic speed, the compressed portion becomes very hot, and the expanded gas behind the shock wave becomes colder. In certain shock tubes elsewhere the temperature becomes as hot as 10,000 degrees. In the Illinois tube the temperature reaches about 600°F.

The tube can also be evacuated—down to a pressure of 1/1000 of an atmosphere (one atmosphere equals 14.7 lbs. / sq. in.), if needed—to simulate lower pressures, such as those found at high altitudes, where most of our modern high-speed planes fly. Evacuation is usually done when a very strong shock is desired to be obtained, for strength of shock waves depends upon the *ratio* of absolute pressures on the two sides of the diaphragm. While the breaking strength of the diaphragm depends upon the *difference* of pressure between the two, in order to obtain a high ratio with a small pressure difference, a low absolute pressure in the low pressure chamber is required. Hence, a partial vacuum is used.

The velocities of the shock waves vary from slightly greater than that of sound, about 1150 feet/second, to about 4000 feet/second in *this* shock tube. These velocities may be measured by allowing the shock waves to pass through a narrow light beam. When they do this they cause a deflection of the beam, which may be detected by a photo-cell and knife-edge combination. Two light beams are usually used, separated by about a foot, and the time interval which elapses between the interceptions between these two beams may be measured on a coronograph. The coronograph which is under construction will permit an accuracy of about ½ microsecond (one microsecond is one-millionth of a second) in the determination of this interval.

Since the shock wave travels with the speeds mentioned above, ordinary mechanical instruments do not permit or give reliable measurements. The flow which follows the shock wave lasts for only a few thousandths of a second, and mechanical gauges do not respond rapidly enough to be used here. These difficulties are dealt with by using optical methods of measurement. These optical methods require a high intensity source of light and a very short exposure time to detect the rapid changes which occur. The usual technique is to use a spark, which lasts about a microsecond, and which provides sufficient light for satisfactory photographic exposures. The photographs are usually taken through an interferometer which gives an indications of the density of the gas. When it is intended only to detect the shock waves themselves, a shadowgraph technique may be used.



The shock tube of Aero Lab "B", in which velocities up to 1.7 times the speed of sound are obtained. (Photos courtesy Aero Engineering Department)

Professor H. H. Hilton is undertaking a research project purely on his own time. What he is trying to do is observe thermal stresses in a body which is being heated. He takes plastic, heats it, and looks at it through polarizers, which show the stresses in varied colors and shades. He is attempting to observe the "creep" of the material in relation to time. More specifically, a circular plastic plate with a hole in the middle is heated by a resistance wire. This project is experimental and under no contract.

Closely connected to his own project, but sponsored by the Air Force, is the contracted research project directed by Professor Hilton. The official title of it is "Thermal Stresses and Visco-elastic Bodies." This research is all theoretical. At high temperatures a body gets what is known as "creep" and stress relaxation. In certain ranges of temperature, the stresses fall off. The fact that material properties are all functions of temperature is the basis of most of the theoretical work in the project. Thus there is a double problem —that of creep *and* that of temperature variation.

The practical applications of the results of this research will be connected with high speed aircraft, aerodynamic heating of the wings or outer skin, deicing, power plant, jets, and rockets.

Research in the field of propulsion is being done at the University of Illinois Airport by Professor McCloy, who is assisted by Dick Smutney. The first design model of a valveless pulse-jet and also the latest in the series, both of which have been conceived and designed by Professor McCloy, were on display at the Engineering Open House March 27-28, 1953. This ram-jet was a major attraction, due largely to the tremendous noise it made while in operation. Professor McCloy is presently under contract to the United States Navy for the development of a modified ram-jet engine. This project is classified; hence, little more can be freely said about it.

Customer: Your dog seems very fond of watching you cut hair.

Barber: It ain't that; sometimes I snip off a bit of a customer's ear.

* * *

Elderly Lady (visiting prison): I'm sure, my poor man, that poverty brought you into this.

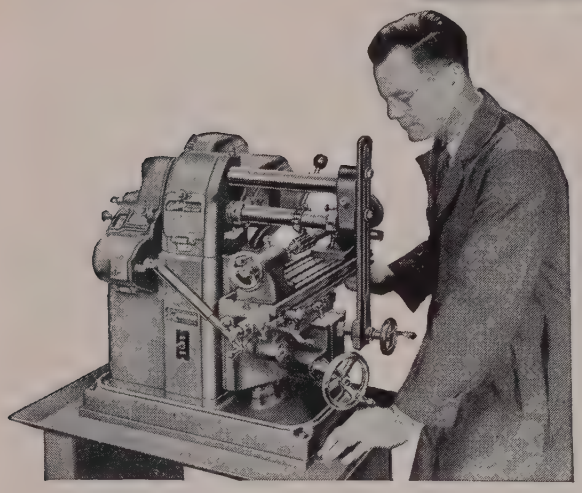
Prisoner: No, madam, I was coining money.

* * *

Customer: Your wife is really a good worker.

Grocer: She sure is. Wish I had a couple more like her.

Another page for **YOUR BEARING NOTEBOOK**



How to give an 8-speed miller greater spindle accuracy

This milling machine has 8 speeds, from 62 to 2870 RPM. To hold the spindle in accurate alignment at these various speeds, design engineers mount it on Timken® precision bearings. Long-lasting milling precision is assured. Spindle accuracy can be controlled because Timken bearings are adjustable. And they provide more than enough capacity for any tool load.

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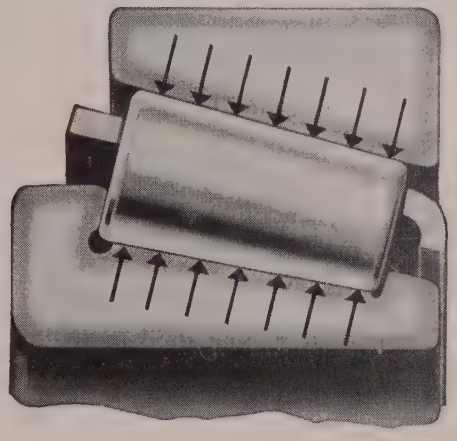

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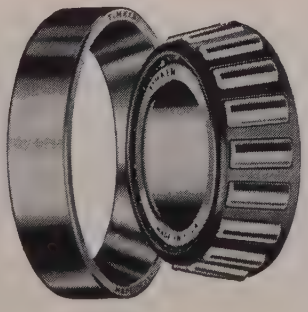

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Navy Pier . . .

CHICAGO GOES UNDER

by Don Schilke, Comm., '56, and Jerry Wheeler, C.E., '56

Doctors tell us we're suffering from a new disease. It is strictly a 20th century development. It has an insidious nature. The results can lead to physical violence or mental breakdown. Its name traffic neurosis.

Chicago loop businesses fear a by-product of this disease. When shoppers become fed up with loop parking facilities, rates, and traffic, they will take their patronage elsewhere. Loop business suffers.

Chicago has constructed new superhighways, arterial streets and boulevards. This modernization of Chicago's traffic system will increase the traffic volume in and around the central business district. Off-street parking is therefore a paramount necessity.

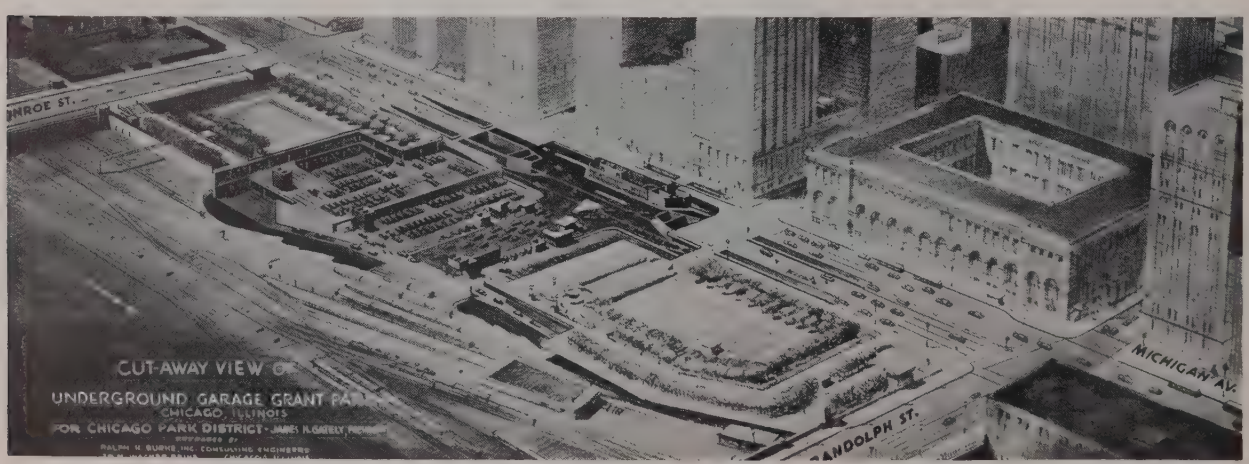
Many proposals have been advanced in recent years to construct an underground garage beneath Grant Park along Michigan Avenue. Time studies and field checks reveal that the adjacent Lake Shore Drive is the most heavily traveled street in the City of Chicago. Twenty-seven percent of the downtown population work within five minutes walking distance of the parking site. Recognized as the most heavily concentrated shopping center of the nation, convenient to hotels, theaters, and office buildings, this garage site possesses advantages unparalleled by any other location in Chicago.

Although private investors have offered to build and operate the new parking project, the Chicago Park District has undertaken its entire development and operation. The estimated $8,300,000 cost was financed by revenue bonds. Because of existing legislation, which prevented any construction from marring the beauty of Grant Park, an amendment to the Chicago Park District Act was passed, which allows the construction of underground parking facilities.

In December, 1952, Ralph H. Burke, Inc., consulting engineers for the project, received 50 bids from various construction companies. Contractors who requested specifications and drawings received more than 1,000 square feet of blueprints. The bid was awarded to the John Griffith & Sons Construction Co. Included in the contract was a $500 a day bonus/penalty clause.

The initial work began in February, 1953, when a landscape contractor removed 131 elm trees from the surveyed area, and the park's statues, balustrades and fountains were placed in storage. Upon completion of the project in November of next year, four feet of soil will cover the portion of the garage under Grant Park, and the landscape will be restored to its former beauty.

Before major earth moving operations could begin, Michigan Avenue traffic



Cutaway view of the Grant Park Underground Garage. (Courtesy Chicago Park District)

THIS NEW AUTOMOTIVE LABORATORY at Standard Oil's Whiting Research Laboratory is now in operation testing and developing new and improved gasolines and lubricants.

They help design the future

• In the laboratories of today, the world of tomorrow is taking shape—test by test, experiment by experiment.

What man will be capable of in years to come, how he will work and play, how he will travel, all depend to a large extent on the fuels and lubricants that will power the machines of the future.

More than a quarter of a century ago Standard Oil opened its first automotive laboratory, and from time to time has enlarged the facilities.

Now Standard Oil has added still another unit. The new building located at Whiting, Indiana, is devoted entirely to the testing and development of automotive fuels and lubricants.

Full-scale testing is conducted in a room containing every needed facility for the measurement and control of operating conditions. The test engines include the principal types used today or anticipated for the future. Each of 16 engines, with its dynamometer, is mounted on a separate concrete foundation, isolated from other parts of the building to eliminate vibration.

In the expansion of our laboratories, young technical men find evidence that the challenge of the future, with its stimulation and rewards, is being met at Standard Oil.

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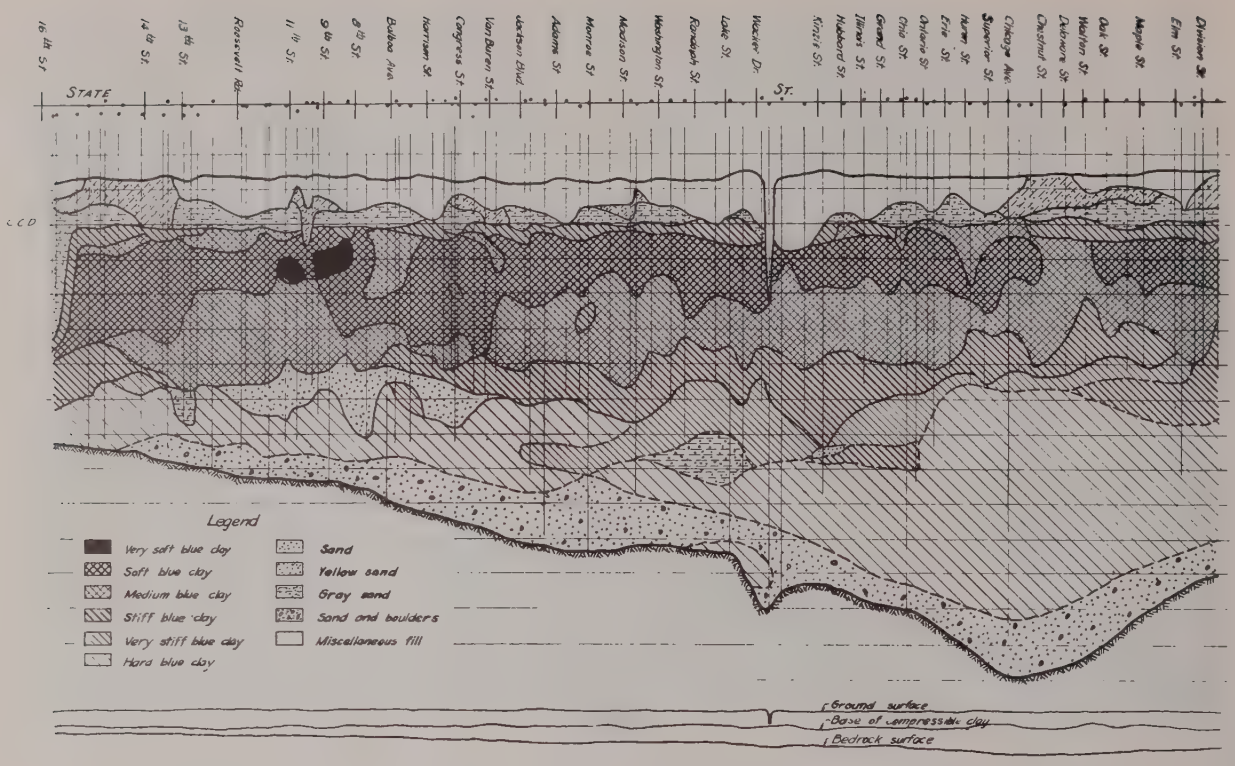
STANDARD



DETAILED PROFILE ALONG STATE STREET

Scales

was re-routed over a temporary road thru the easterly half of Grant Park. A 24-inch water main, a 20-inch gas main, a 7-foot sewer, fire and police alarm systems, and electric power facilities were gathered up from under Michigan Avenue and moved to the west curb.

The underground garage will consist of three parts: the mezzanine, which will hold 130 cars, the main floor, 1,037 cars, and the lower level, 1,192 cars, totaling a 2,359 capacity.

Ramps on Michigan Avenue will provide two entrances and two exits. As the motorist enters the garage, he will have a choice of self-parking or letting an attendant handle it. The rates for attendant parking will be slightly higher. After entering the desired lane, each driver will be given a stamped ticket which records the date, time and last four digits of the license number.

Stalls which are occupied will have red ceiling lights. Orange lights will indicate attendant parking areas. Green ceiling lights will call attention to empty parking spaces.

After parking his car, the motorist will walk to the west side of the garage where he may take an escalator up to Michigan Avenue at either Washington Boulevard, Randolph or Monroe Street, thus eliminating the need of crossing Michigan Avenue at grade level.

A great deal of consideration has been given to that old American nemesis —speed. Because the supporting columns are spaced 29′ apart, the motorist will be blessed with 9′ by 18′ parking stalls. This large area will facilitate easier and faster parking.

The cashier booths will be located at the north, south and central sections, there-by shortening walking distances for self-parkers and attendants. The use of computers, totalizers and an inter-communication system will expedite all operations.

The cost of parking in the underground garage will be less than that of the average parking lot in the northeast section of the loop, especially if the motorist chooses to park his car without the help of an attendant. The average attendant parking rate in Chicago is 65c for one hour and $1.25 for nine hours, with self-parking rates at 45c and $1.10.

Cost of construction is estimated at $8,300,000 or $3,515 per stall. It is estimated that the total yearly revenue will gross $1,230,750 with a $545,500 net.

Walls, columns and floors will be constructed of reinforced concrete. The waiting room, rest rooms and locker rooms will be heated by a low pressure steam system and finished in glazed tile glass set in aluminum. The ramps and receiving lanes will have radiant heating for automatic snow removal. Walls and fire doors will divide the garage into fire protection areas, and fire alarm temperature rise detectors are to be installed throughout.

The safety and comfort of motorists has been given every consideration. Ventilation is to be mechanical with a maximum change of air every 3.6 minutes. The intensity and arrangement of ramp lighting is planned to effect a minimum contrast between sunlight and underground illumination.

The worst thing about getting old is to have to listen to a lot of advice from one's children.

—Lake Mills Graphic

* * *

Eskimo's Wife: You look terrible this morning, dear!

Eskimo: I'm a nervous wreck. Those darn dogs must've barked two months last night.

DOW

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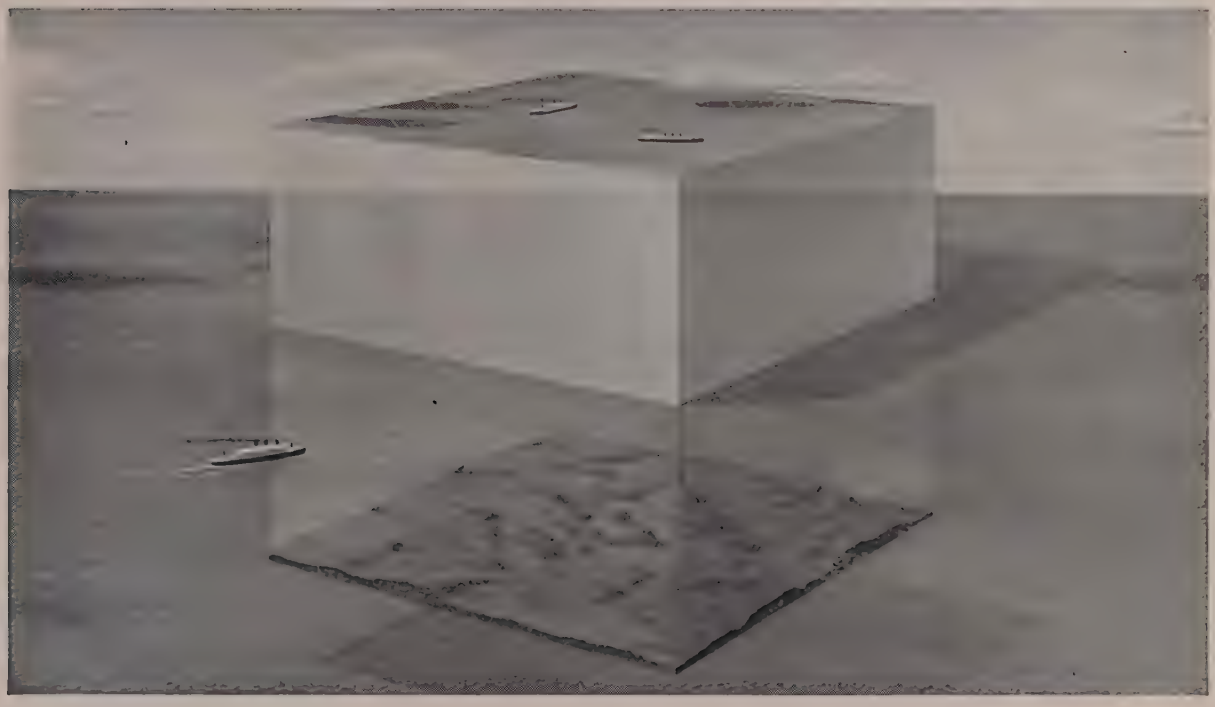

Today, when this nation is confronted with a crisis in our supply of many raw materials, it is of immense significance that the sea around us contains an almost unlimited supply of Magnesium. For Magnesium is light, strong, practical and versatile—the answer to many manufacturers' needs.

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Dow's Booklet, "Opportunities with The Dow Chemical Company," especially written for those about to enter the chemical profession, is available free, upon request. Write to THE DOW CHEMICAL COMPANY, Technical Employment, Midland, Michigan.

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DOW

3-D

by Eric Aagaard, M.E., '53

The science of photography has made enormous advances since its early days when it took ten minutes to expose a photographic plate in bright sunlight. Today we have photographs and motion pictures which quite accurately reproduce scenes as they might actually appear as to lights and shades, perspective, color, definition, and movement. These pictures are nearly perfect in all but one very important respect — they do not reproduce a scene in its original solidity and relief. When we can produce a photographic reproduction which gives the effect of looking through a window at the original scene instead of seeing a flat sheet of paper or movie screen, we will have come much closer to producing a perfect picture; one which is indistinguishable from the original.

The science dealing with the seeing of objects in three dimensions is known as stereoscopy. Men have been speculating as to the causes of this phenomenon since the time of Euclid, who mentioned it in his writings in 280 B. C. Numerous conjectures were advanced after this time, but all the early explanations were extremely vague. It was not until the early part of the sixteenth century from a manuscript left by the famed Florentine painter, scientist, and engineer, Leonardo da Vinci, that the first definite theory of binocular vision was known; the explanation universally accepted today.

The stereoscopic effect in seeing is primarily due to the fact that each human eye sees a slightly different view of a scene from its mate. This may be demonstrated by a simple experiment. Hold a fairly thin book with its back toward you about ten inches in front of your face. When your left eye only is closed, you should see the back and right side of the book. When the left eye is opened and the right eye is closed, you will see the left side and back, but not the right side.

If a small sphere were substituted for the book, each eye would see almost one-half of its total surface. Together the eyes would see more than one-half the total surface, since each eye has a slightly different view of the sphere. This seeing around an object is interpreted by the brain, which fuses the images from the eyes, as a sensation of depth and solidity.

A factor in vision which tends to make some objects appear more distant than others is known as convergence. This is the angle formed between the rays of light entering each eye from the same point on an object. When an observer is looking at an object about ten inches from his face this angle is about fifteen degrees; when the object is at a very great distance the angle is very nearly zero. It is evident that convergence angle varies in an inverse relation with object distance.

Since the region of most acute sight is the center of the field of vision, the eye is equipped with muscles which turn the eye ball to bring the object viewed to the center of the field. Since the center of the visual field of each eye would now correspond to a side of the angle of convergence with the object, the eyes must turn inward when looking at the object.

Convergence may be demonstrated by the following experiment. About a foot before your face hold one forefinger vertical. While holding the attention of your eyes on the finger observe objects beyond it. These further objects will appear greatly blurred since the eyes are trained on only the angle of convergence substended by the finger. If the eyes are now trained on objects beyond the finger, the finger will apparently split into two. Again this may be explained by the dissimilar angles of convergence.

Accomodation is another factor which plays a role in stereoscopic vision, although not as important a one as those factors mentioned above. Accomodation refers to the ability of the eye to focus the image formed by the lens onto the retina. This situation is analogous to the focusing of a camera and is not dependent upon the use of both eyes. Some people, particularly older ones, who do not possess the full power of accomodation may remedy this defect with bifocal glasses.

There are other factors which influence our sense of stereoscopic vision. When we close one eye we still sense more depth and solidness than could be attributed to accomodation alone. Strictly speaking this sensation could not be called stereoscopic vision at all, since it is due to our knowledge of existing conditions. We know the effects of perspective, light and shade, atmosphere, the size of certain objects, and the like. It would be difficult to determine the size and relative distances of irregularly shaped objects placed against a black background and viewed with one eye only.

We may perform another simple experiment. Place a coin on a table so it projects partly over the edge. Close one

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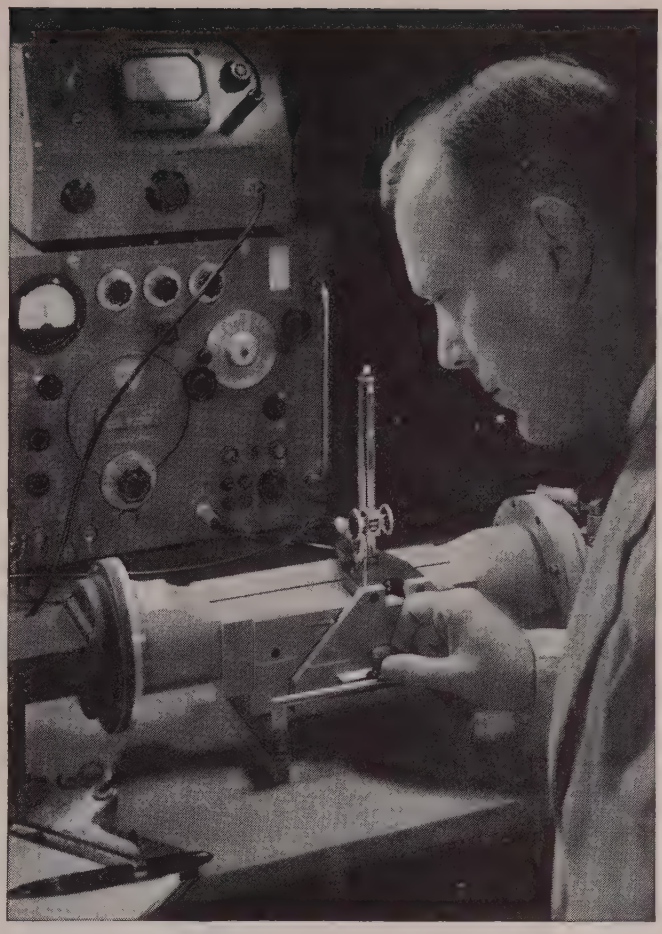

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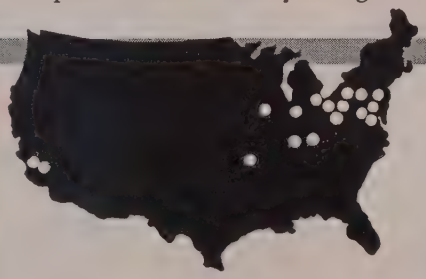

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eye, walk a step or two away from the table, turn around, walk up to the table, and without hesitation knock the coin from the table with your forefinger. You will probably fail nine times out of ten, although you should have no trouble if you repeat this experiment with both eyes open. It follows that true stereoscopic vision is possible only when we use both eyes. The psychological reactions involved in fusing and interpreting the images from the two eyes are complex and not well understood. It is not the purpose of this article to discuss these reactions but rather to show what physical conditions are necessary to produce stereoscopic effects artifically.

It should be mentioned that some people do not possess the faculty of stereoscopic vision. The reason may be these people depend almost entirely upon one dominant eye for vision, or they may have one eye which is considerably weaker than the other.

The Stereo Viewer

As mentioned earlier each of the human eyes sees a slightly different view of an object. If a reproduction of the proper view can be presented to each eye the major condition for stereoscopic vision is satisfied. When mounted side by side the reproductions may be viewed without artifical aid with a little training on the part of the observer. These stereograms, as they are often called, first took the form of drawings long before the dawn of photography. The earliest known examples of these drawings were made by the Neapolitan, Giovanni Battistá della Porta (1538—1615), who is often credited with the invention of the camera obscura and the magic lantern. There are difficulties which arise when stereograms are viewed directly. The eyes have trouble fusing the two reproduced views, since the required angle of convergence is less than normally required at the actual viewing distance. This unnatural condition causes eyestrain and some distortion of the picture. Since the eyes cannot readily diverge, the distance between the centers of the individual views cannot be greater than the distance between the eyes. This limits the width of the individual views to about two and one-half inches, therefore requiring the views to be held unnaturally close if any details is to be seen.

Eliot's stereoscope, a viewing device which partially eliminated these difficulties, was introduced in the third decade of the last century. It consisted of an oblong rectangular box with two peep holes for the eyes in one end and a single hole in the center of the opposite end. To view a stereogram with this device it was necessary that the lines of sight cross, that is, the left eye saw only the right view of the stereogram while the right eye saw only the left view. The views were, of course, mounted in the reverse of their natural order. There was no restriction on the size of the views. The instrument could be used by most people despite the unnatural angle of convergence.

The first completely practical stereoscope was introduced by the scientist, Sir Charles Wheatstone, in 1883. The two views of the stereogram were separated and placed face to face in parallel planes on either side of the observer's head. The observer saw reflected images of the views through two mirrors, one placed before each eye. The views could be as large as desired and placed at any convenient distance from the observer. The natural angles of convergence could be obtained. Since mirrors were used the stereo views had to be reversed reproductions, that is, reproduced writing on the views read from right to left rather than from left to right. In an improved version of the Wheatstone stereoscope, which is used for aerial survey work today, a second pair of mirrors was introduced to allow the use of normal unreversed stereograms. The inherent bulk of this instrument was its principle disadvantage.

In 1849 the Scot, Sir David Brewster, described a compact stereoscope in which the views were mounted side by side. Between each view and the eye was placed a thin prism which displaced the image toward the center of the field of vision, thus producing natural convergence. In latter models the prisms were replaced by prismatic lenses which enlarged the images as well as providing convergence. Prismatic lenses are half sections of simple convex lenses. The famous parlor stereoscope common to the homes of our grandparents was of the Brewster type. These popular instruments ranged from cheap mail order house productions to expensive models mounted in cabinets inlayed with semiprecious stones. The views were mostly inexpensive halftone reproductions on $3\frac{1}{4} \times 6\frac{1}{4}$ inch cardboard mounts. The introduction of other entertainment mediums, such as motion pictures, were chief causes of the parlor stereoscope's downfall. We should not lament its loss, because its often poor construction produced eyestrain and the cheap halftone reproductions used in the stereograms left much to be desired from a technical standpoint. However, before we leave the parlor stereoscope to its grave, it should be mentioned that Oliver Wendell Holmes invented the popular form of this instrument.

It should be evident that magnifying lenses before the eyes permit the use of stereographic views of small size, the only restriction being that the views provide adequate definition of fine detail. When the individual views are two and one-half inches wide or less, the centers of the views may be placed on the axis of the eyes, thus allowing the use of full convex lenses in the place of prismatic lenses. The optician Hermagis constructed an instrument of this type in 1856, followed by the German scientist, Helmholz, in 1866. Well made instruments of this type produce the finest stereo effects presently obtainable. The use of well ground achromatic lenses eliminate the eyestrain associated with the prismatic lenses of the Brewster stereoscope. Practically all modern instruments are of this type and are usually equipped with focusing devices, interocular distance adjustments, and built-in sources of illumination.

The beautiful stereograms obtainable from the use of modern full-color photographic films have been largely responsible for the present great popular interest in three dimensional photography. Before a further discussion of viewing is made, it will be well to mention the technique of producing photographic stereograms.

Making the Stereo Photograph

The two views of the stereogram may be made with an ordinary still camera which is moved the interocular distance between exposures. Suitable brackets are available at photographic supply houses to give this restricted movement to a camera mounted atop an ordinary tripod. Since two separate exposures must be made, this system is not suitable for photographs of moving objects. Stereograms are made most conveniently with a twin-lens camera; essentially the optical systems of two cameras mounted in the same body. Since the lens and shutter adjustments of such cameras are tied together, the twin-lens camera is no more difficult to operate than an ordinary single-lens camera. Several excellent twin-lens stero cameras designed to use 35 mm. color film are available to the amateur or professional photographer.

A simple device available to the photographer allows the use of any single lens camera for making one exposure stereograms. It is a small box about three inches long containing a train of prisms (or mirrors depending upon the quality of the device). The stereo images are transmitted from two openings in one side of the box by prisms to a single opening in the back of the device which fits over the lens of a conventional camera. The two stereo images are formed on the film area normally occupied by a single image. The device is also available for small movie cameras.

THE DU PONT DIGEST

DU PONT SCIENCE AND ENGINEERING GRADUATES MEET THE PUBLIC IN

Technical Sales

James A. Newman, *B. S. in Ch. E., North Carolina State '40, discusses study of optimum settings and conditions for carding nylon staple with Prof. J. F. Bogdan of North Carolina State's Research Division.*

More and more, industry is on the lookout for technically trained men and science majors who have an interest in and aptitude for selling. A number of departments at Du Pont prefer men with such training for sales positions. A technical understanding of the properties of a substance helps a man do a better selling job—and offers the customer better service.

Because of the diverse applications of Du Pont's many products, there is a need for sales representatives with widely varying technical backgrounds. There are problems involving chemistry and many types of engineering in such fields as plastics, ceramics, textiles and many others.

Technical men may work in direct sales, sales service, or sales development groups, depending on departmental organization. In some cases technical men handle all phases of selling. In others they deal mainly with customer problems. Some departments also maintain a sales development section that works on technical problems connected with the introduction of a new product or a new application for an established one.

Ivan R. Smith, *B.S. in Ch.E., Kansas State University '40 (right), advises the operator of a galvanizing machine on the efficient use of a Du Pont flux.*

Edgar G. Boyce, *Ashland State (right), helps a customer improve his method of applying silicate adhesive in the manufacture of corrugated boxboard.*

Here are examples of the kind of problems attacked by technical men in Du Pont sales groups:

1. Find a more economical way to apply sodium silicate used in making corrugated paperboard. Du Pont men, as in many other instances, were able to make substantial savings for the customer.

2. Introduce fabrics of "Orlon" acrylic fiber for use in dust filtration. This involved evaluation and modification of filter fabrics in cooperation with makers of dust-control equipment, and with plant personnel having serious dust-recovery problems.

3. Reduce the time needed for processing motion-picture film used by race tracks. Technical service men carried the problem to a research group which developed an emulsion that could be processed in about one-third the former time.

Technical men interested in sales work at Du Pont usually acquire needed background in a laboratory or manufacturing plant. Depending on their interest and abilities, they may then move into technical sales service, sales development, or direct sales.

In any of these fields, the man with the right combination of sales ability and technical knowledge will find not only interesting work but exceptional opportunities for growth in the Company.

College graduates with many types of technical training find opportunities at Du Pont. Write for your copy of "The Du Pont Company and the College Graduate." Address: E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Building, Wilmington, Delaware.

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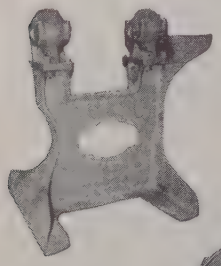
MOST products can be built stronger, more rigid with welded steel construction than possible any other way. Steel is 3 times stronger and twice as rigid as traditional gray iron. As a result, usually less than one-third the actual weight of metal is required.

Pound for pound, steel sells for a third of what gray iron costs at the cupola. This lower cost per pound plus fewer pounds needed to carry equivalent load means that initial material costs can be cut as much as 85% of prices charged for castings alone to which fabrication, of course, must be added.

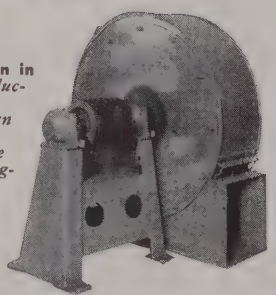
In addition to its inherent superior physical properties, steel is easily formed to efficient engineering shapes such as I beams and channels. Thin wall structural sections are possible by concentrating material at outer edges in load carrying members where each pound of metal does the most good. When steel is utilized to the fullest, a product of welded construction generally can be manufactured for half the cost.

The examples show how a typical machine part was changed over from cast iron to welded steel construction. The cost saving of 50% resulted from less material and expense by eliminating several machining operations such as milling and drilling. Cleaning and painting operations in the former cast design were also avoided. The new welded steel base is both stronger, more rigid and has a clean streamlined appearance to improve selling appeal.

Latest information on designing structures to save steel and lower cost is presented in 1200 page "Procedure Handbook of Arc Welding Design and Practice". Price only $2.00 postpaid in U.S.A.



Original Cast Construction *required 41% more material. Heavier weight increased handling costs in manufacture, shipment and installation.*



Present Design in Steel *cut production cost 50% . . . New design is actually stronger, more rigid than original. Modern appearance has greater selling appeal.*

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Group Viewing

To this point the discussion has been limited to viewing devices used by only one individual. The recent interest in three dimensional photography demonstrated the desirability of audience viewing of stereograms. Of the many group viewing methods proposed, the presently most practical and commonly used was developed in 1936 by Edwin H. Land for projected still slides and motion pictures. The method involves mounting two projectors side by side, each projector presenting one of the views of the stereo pair. A polarizing filter, that is, a material which transmits light vibrating in one plane only, is mounted in each projector. The two images projected on the screen are polarized at right angles to one another.

Polarized light will pass through a polarizing filter only when the plane of polarization of the filter is nearly the plane of polarization of the transmitted light. In the Land system the spectators are provided with spectacles containing polarizing filters arranged at right angles so that each eye sees only one of the projected stereo images. Amateur equipment of this type for projecting movies and slides is available on the open market. The three dimension films presently being produced and distributed by the motion picture industry use the polarizing system.

Stereoscopic motion pictures should not be confused with motion picture systems involving the use of a curved screen, such as the Cinerama. These latter systems depend upon the wide screen to give the spectator the sense of being among the actors on the screen; they do not produce true stereoscopic effects.

It is entirely possible to produce stereograms requiring no viewing device or special adaptation by the spectator. Store window displays often use the line screen stereo system. The original exposure is made with an ordinary single lens camera. A screen, made of fine vertical lines ruled on a glass plate, is placed in contact with the photosensitive face of the film within the camera. The spaces between the ruled lines are equal to the width of the lines. After one exposure is made, the screen is shifted the width of a ruled line, the camera is moved laterally the interocular distance, and the second exposure is made on the previously unexposed portions of the original negative. Thus the processed photograph will contain both views of the stereo pair in alternate vertical strips.

Viewing is accomplished with the aid of another vertically ruled screen placed a fraction of an inch before the photograph. When properly placed, this screen will allow each of the spectator's eyes to see only the portions of the photograph showing the proper stereo view. Since proper viewing conditions are dependent upon the position of the spectator with respect to the screen and the photograph, the line screen stereo system does not give entirely satisfactory results.

A potentially more perfect system involves the use of a lenticular film. The lens of the camera used must be extremely wide, perhaps on the order of eight or more inches. The photosensitive coating is on the side of the film away from the lens, thus the transparent base of the film is between the lens and the photosensitive coating. The uncoated surface of the film base is a series of cylindrical lenses forming a corrugated pattern. Each cylindrical lens, together with the strip of photosensitive material immediately behind it, is in itself a miniature camera. After the single exposure is made, the film is given reversal type processing, that is, the positive photographic image is produced on the original film. The film, when illuminated from behind, now produces stereoscopic effects to the unaided eye. An interesting feature is the spectator's ability to look behind objects in the three dimensional picture, that is, the spectator may, by moving his head, see objects in the picture originally obstructed by other objects in the foreground.

The practical applications of stereoscopy are by no means limited to pictorial photography. Stereoscopy finds wide applications in topography, microscopy, radiography, and astronomy.

For many years the center of pictoral stereoscopic photography has been Europe. However, since the Second World War precision stereoscopic equipment has been produced in large quantities in this country and a revived interest in stereoscopy is developing. Three dimensional photography is gaining a position of prominence in our lives.

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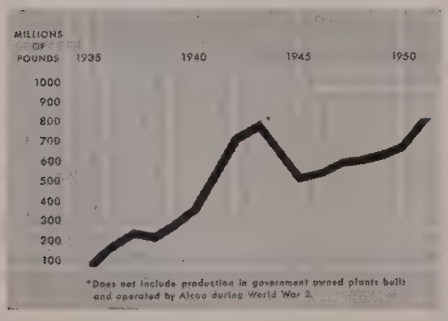
Is part of your future being built here?

Here you see the beginning of another addition to Alcoa's expanding facilities. This plant, at Rockdale, Texas, will be the first in the world to use power generated from lignite fuel and will produce 170 million pounds of aluminum a year. This and other new plants bring Alcoa's production capacity to a billion pounds of aluminum a year, four times as much as we produced in 1939. And still the demand for aluminum products continues to grow. Consider the opportunities for you if you choose to grow with us.

What can this mean as a career for you?

This is a production chart—shows the millions of pounds of aluminum produced by Alcoa each year between 1935 and 1951. Good men did good work to create this record. You can work with these same men, learn from them and qualify yourself for continually developing opportunities. And that production curve is still rising, we're still expanding, and opportunities for young men joining us now are almost limitless.



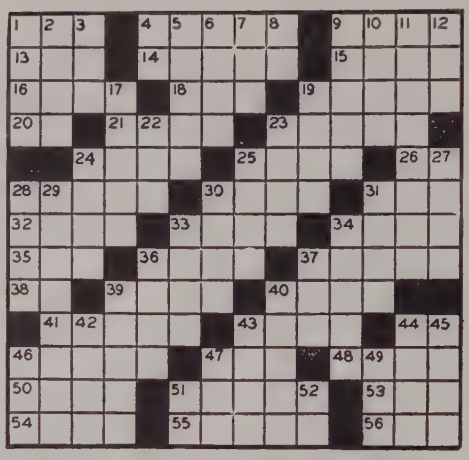
Ever-expanding Alcoa needs engineers, metallurgists, and technically minded "laymen" for production, research and sales positions. If you graduate soon, if you want to be with a dynamic company that's "going places," get in touch with us. Benefits are many; stability is a matter of proud record; *opportunities are unlimited.*

For more facts, consult your Placement Director.

Alcoa Aluminum

ALUMINUM COMPANY OF AMERICA

Crossword Puzzle



ACROSS

1. Important part of a hydro-electric plant
4. Sharp
9. Seth's grandfather: Bible
13. Metric surface unit
14. Synthetic rubber
15. Molten rock
16. Marshes
18. A distilled spirit
19. Surgical bristle
20. Silvery metal: chem. symbol
21. The one over there
23. Block to keep a wheel from turning
24. Bench
25. Gash
26. Indefinite one
28. Exclamation of impatient contempt
30. Associate of Felix Savart in 1820
31. Bustle
32. Small particle
33. Flash of lightning
34. Thick part of clabber
35. Billiard stick
36. Stronghold
37. Light boat
38. Sound of hesitation
39. Stratagem
40. A pursuit
41. Developed an electric telegraph in 1834
43. Near me
44. Parent
46. Taut
47. Electrically charged particle
48. Developed an all-glass light bulb in 1879
50. Custom
51. Decorate
53. Improve with time
54. Individuals
55. Greek sylvan deity
56. Fresh

DOWN

1. Built an electric locomotive in 1883
2. Tract
3. Enlisted soldiers
4. Hebrew month
5. First violinist to broadcast on the radio
6. One
7. Color produced by sunlamps
8. Plural suffix
9. Watchful
10. Facts
11. Italian physicist, defined the molecule in 1811
12. Aided William Sawyer develop an electric lamp in 1875
17. Often used in electric generating plants
19. Impale
22. Turn to the left
23. Opening for insertion of coins
24. Sliding contact resting on a third-rail
25. Sediment
27. Point at rest in a vibrating wire
28. Step
29. English physicist, made an electromagnet in 1825
30. Afflict with ennui
31. Relative
33. Employer: colloq.
34. Walking sticks
36. Protection against overloads in a circuit
37. Mongrel
39. Corrodes, as iron
40. Constructed the first electromagnetic motor in 1829
42. English queen daughter of James II
43. Derisive shout
44. Invented a "galvanic multiplier" in 1837
45. All over again
46. Pair
47. Mrs. Eddie Cantor
49. Pallid
51. Like
52. City "45 minutes from Broadway" initials

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New society . . .

General Engineering Society

by Bob Nieman, Gen. E., '55

This spring the administration of the Curriculum of General Engineering was transferred from the Dean's office to the Department of General Engineering Drawing and the name of the department was then changed to General Engineering. While some members of the former Drawing Department handled the details of registration and advising of the General Engineering students, the department is now charged with complete responsibility for this curriculum.

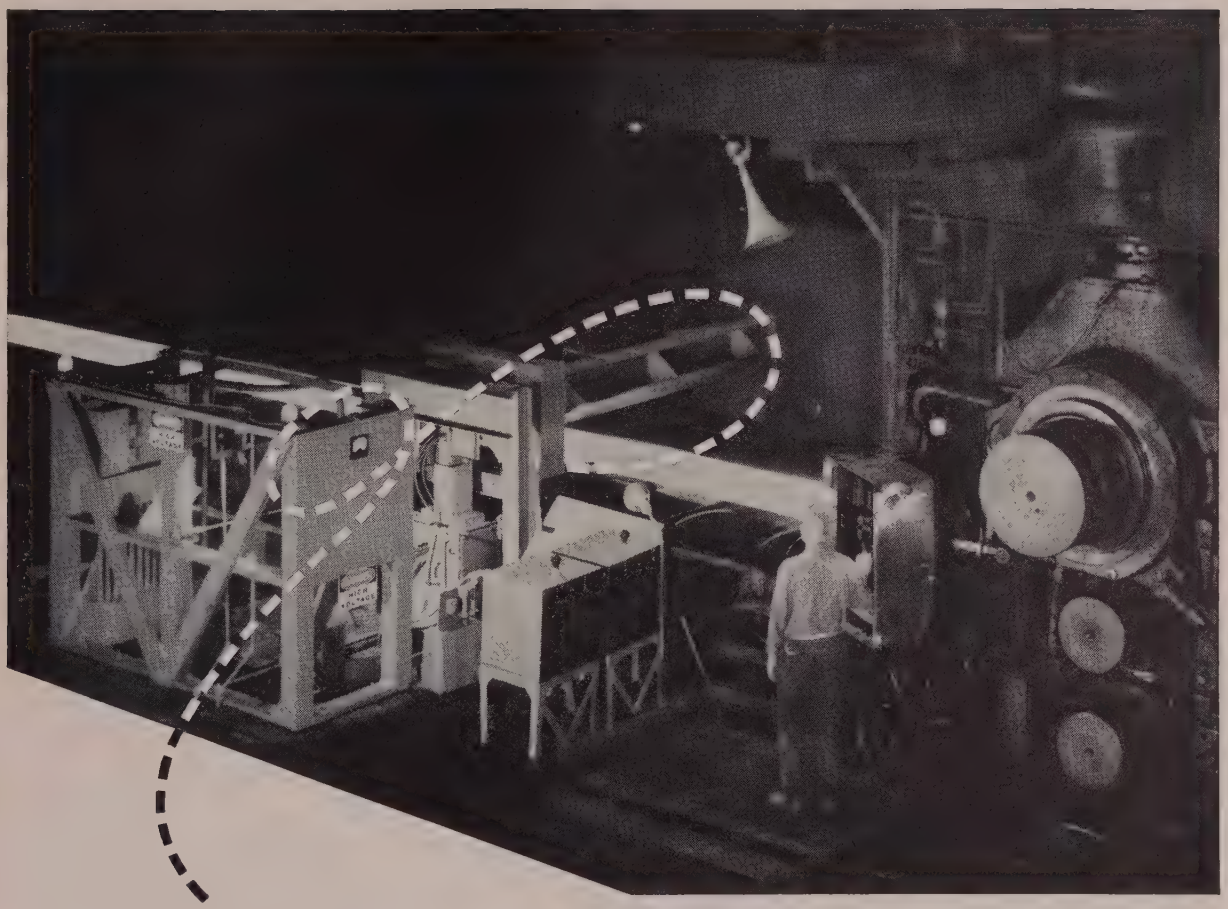
The General Engineering curriculum provides the student with the sound fundamental core of an engineering education. Its chief appeal lies in the fact that it permits the student to specialize in areas of training not readily available in other curricula. The basic core permits the choice of electives which are useful for a career in engineering business or salesmanship, technical journalism, or teaching. A proper selection of electives may further provide the ground work for employment in engineering research or geology.

Upon formation of the new Department of General Engineering both the students and faculty expressed interest in a society for General Engineers. Heretofore the General Engineering students were not represented as a group and existed more or less independently with no definite ties on campus.

Interest was translated to action when the Student-Faculty Relations Committee of the Department of General Engineering called a meeting for all General E.'s with the purpose in mind of reestablishing the Illinois Society of General Engineers. The General Engineers had at one time their own society but it was disbanded due to the war.

The enthusiasm expressed at the first meeting was encouraging to all concerned. Consequently plans were laid for the coming semester and officers were elected as follows: President, Bill Getzen; Vice-president, Jack Kiest; Secretary, Bob Neiman; Treasurer, Dick Somerville.

Beginning next fall, the Society will attempt to further the interests of the General E. student in campus affairs. To acquaint the students with their fellow students and the faculty, to keep the members informed of current affairs in industry and to promote greater interest in the profession will be among the objectives of the society.



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Under that white-hot strip of steel is an X-ray tube. Close above the steel is a specially-designed electronic measuring device.

As the steel strip speeds by at half a mile a minute, a ray beamed up through the steel is automatically measured. The results on a dial before the eyes of the "roller" give him a continuously accurate check on the thickness of the flat-rolled steel down to thousandths of an inch.

Thus, Republic employs modern science to make possible better thickness control of steel sheets and strip.

Perhaps, if you've never worked for a steel manufacturer, or sold a basic material, the import of an X-ray measurement may not raise you to high emotion. But customers know it saves them money because it avoids a lot of reject material. They have more confidence in X-ray-measured steel. They tend to favor the Republic man.

When you become part of an organization, you'll want your company backing you up with new ideas—not just standing behind you.

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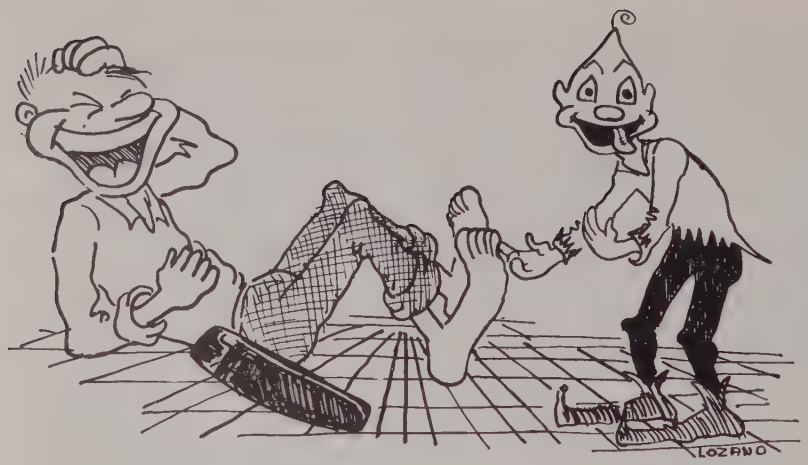

TECHNOCRACKS

"I've got a job at last, Dad," the young actor reported. "It's a new play and I take the part of a man who has been married twenty years."

"Splendid," said the father. "That's a start anyway, my boy. Maybe one of these days they'll give you a speaking part."

* * *

Al: I was supposed to make my stage entrance after the baboons.

Pal: Why didn't you?

Al: They might have thought it was an encore.

* * *

A young actor had made good in Hollywood to a certain extent. On a trip to his home town, the younger element of the town planned a great celebration in his honor.

"Please," the young actor said modestly to the celebration ring leaders, "let's not have undue fuss. Treat me the same as you would Bob Hope."

* * *

"Two hundred dollars for an electric refrigerator? That's too much," said the prospective buyer and walked out of the store.

The next morning he ordered a refrigerator over the phone, and requested immediate delivery.

"Might I ask what made you change your mind?" asked the salesman.

"Certainly," replied the customer. "When I came home yesterday my wife was leaning over our old icebox and I gave her a playful pat. Without looking up, she said, "Fifteen pounds today, darling."

* * *

He kissed her in the garden,
It was a moonlight night,
She was a marble statue,
He was a little tight.

That modernistic furniture confuses me. The other night I was visiting a friend who had nothing but modernistic furniture in his apartment. I couldn't tell a chair from a table until I asked him where an ash tray was and he said I'd been sitting in it for the past half hour.

* * *

The young widow was attending a seance and after the usual routine the spiritualist announced that he had a message from her departed husband to send him a package of cigarettes.

"Where shall I send them?" she asked. "He didn't give an address."

"Well," solemnly replied the spiritualist, "you notice he didn't ask for any matches."

A man was introduced to a circus sword swallower. Not having seen a sword-swallower before, he asked him to demonstrate his art, whereupon the fellow apparently swallowed some pins and needles.

"But," protested the man, "those are not swords—they're pins and needles."

"I know," was the reply, "I'm on a diet."

* * *

A sparrow built a nest on an electric line pole and the hillbilly climbed up to see if the eggs had hatched. The higher he got the more frantic the mother bird became, swooping, swirling and chattering angrily.

A moment later he touched the live wire and was knocked to the ground unconscious. As he opened his eyes and saw the still angry bird, he sadly shook his head. "What a wallop," he muttered, for such a little bird."

* * *

A near-sighted man lost his hat in a strong wind. He ran after it, but every time he was about to catch up with it, it was whisked away from under his hand. After ten minutes he was exhausted.

Then a woman screamed at him from a nearby farmhouse.

"What do you think you're doing?"

The man explained that he was merely trying to recover his hat.

"Your hat!" exclaimed the woman. "It's over there by the wall—you've been running the legs off my little black hen!"

* * *

"Johnson is so conceited."

"Yes, on his last birthday he sent a telegram of congratulations to his mother!"

One day of feeling better doesn't mean you're cured

EVER HAVE FLU, feel better, and go out too soon—only to have a relapse worse than the first attack?

For years the world has been sick. "Something-for-nothing," Welfare State, Socialism, "more-pay-for-less-work"—the disease has different names at different times and places, but it's the same trouble—loss of energy, ambition, faith-in-yourself.

Now much of the world and especially this part of it is feeling better; we think we'll live—as this is written it looks as though more housing, lower prices, lower taxes, and most important of all, less war, are in prospect. BUT—

Don't let's take it too easy too soon. The fever of inflation and debt have wasted the nation's strength and substance which have to be built back. If we continue our tried and true American medicine of hard work, and add the convalescent tonic of thrift, we'll really recover. But as any doctor knows, this first surge of "feeling better" is the dangerous stage:

A relapse could kill us.

Warner & Swasey is always interested in talking future opportunities to young men of ability and character. Write Charles Ufford.

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YOU CAN PRODUCE IT BETTER, FASTER, FOR LESS WITH WARNER & SWASEY MACHINE TOOLS, TEXTILE MACHINERY, CONSTRUCTION MACHINERY

Push-Button Lacquer

CHEMICAL PROBLEM...

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SOLUTION . . .

. . . aerosol lacquers, made with nitrocellulose and resins produced by Hercules. These quick-drying sprays, readily applied at the touch of a finger, restore original color to any lacquered or baked enamel surface.

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This is but one example of the far-reaching chemical developments in which you could participate at Hercules—in research, production, sales, or staff operations. It suggests the ways Hercules' products serve an ever-broadening range of industries and end-uses.

Hercules' business is solving problems by chemistry for industry . . .

. . . soaps, detergents, rubber, insecticides, adhesives, plastics, paint, varnish, lacquer, textiles, paper, to name a few, use Hercules® synthetic resins, cellulose products, chemical cotton, terpene chemicals, rosin and rosin derivatives, chlorinated products and other chemical processing materials. Hercules® explosives serve mining, quarrying, construction, seismograph projects everywhere.

HERCULES

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Opportunities Unlimited

for all types of engineers

CHANCES are—if he has what it takes—a young engineering graduate will find at General Motors the career opportunity he's seeking.

And there are sound reasons why.

In the first place, General Motors makes so many different kinds of products, there is need for almost every type of engineering skill. These products range from automobiles and trucks to refrigerators, fractional horsepower motors and Diesel engines. GM defense contracts include shells, bombsights, range finders, tanks and gas turbine engines.

Yet, this great variety of work is widely distributed among GM's 33 manufacturing divisions, its 111 plants in 55 towns and cities throughout the United States. So although each division has its own engineering department, each can count upon the facilities of GM's central research and engineering laboratories.

It's this combination of big-time opportunity and local intimacy that fosters so many notable engineering careers at General Motors. In fact, many of the top positions at GM right now are occupied by engineering school graduates.

Why not think about this, as your time of decision draws near? Your College Placement Office can arrange for an interview with our GM College Representative the next time he visits your campus. Or if you prefer, write direct to us.

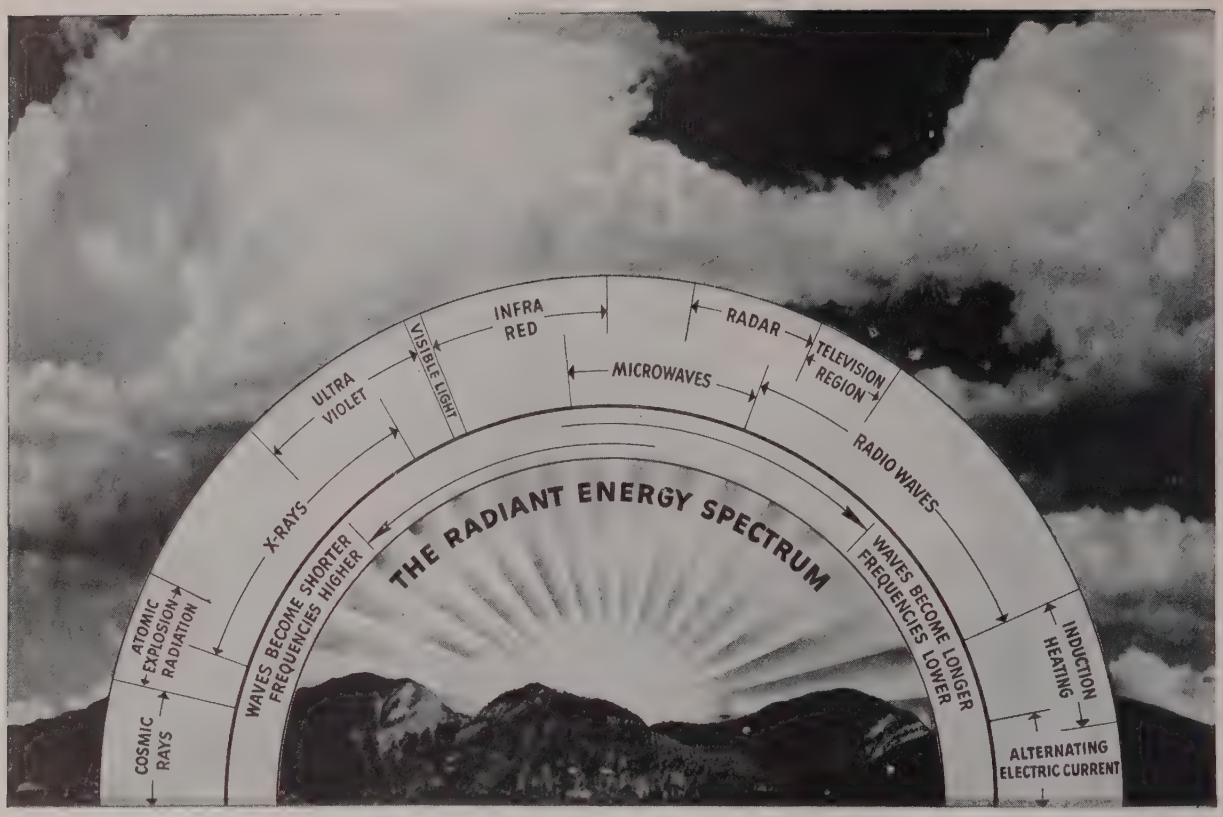
GM positions now available in these fields:

MECHANICAL ENGINEERING	• ELECTRICAL ENGINEERING
METALLURGICAL ENGINEERING	• INDUSTRIAL ENGINEERING
CHEMICAL ENGINEERING	• BUSINESS ADMINISTRATION

Summer jobs available — for engineering undergraduates who want practical experience

GENERAL MOTORS CORPORATION

Personnel Staff, Detroit 2, Michigan



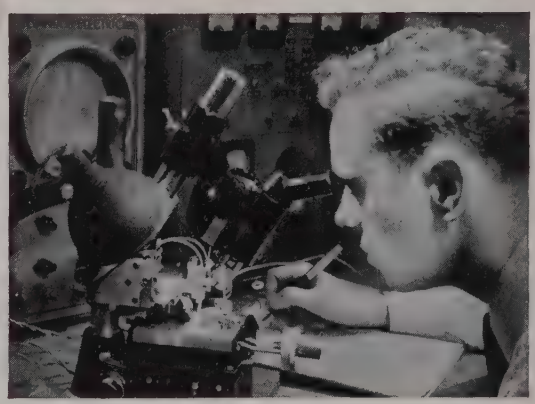
This is our HORIZON

This is the "radiant energy spectrum" — the horizon for the 1600 professional engineers engaged in research and development work at Sylvania's more than a dozen laboratories.

The research and development under way at Sylvania's laboratories reaches, in some way, into virtually every phase of this spectrum. In the broad fields of *lighting, radio, electronics, television,* Sylvania engineers are constantly finding new challenges to stimulate their imagination, new opportunities to further their careers in a steadily growing company.

Sylvania offers college graduates expanding opportunities to build a truly successful and challenging professional career.

For information on Sylvania's program for graduating engineers, see your Placement Office today — or you may write directly to Sylvania's Supervisor of Technical Employment.



A Sylvania scientist uses a micro-manipulator to adjust a transistor.

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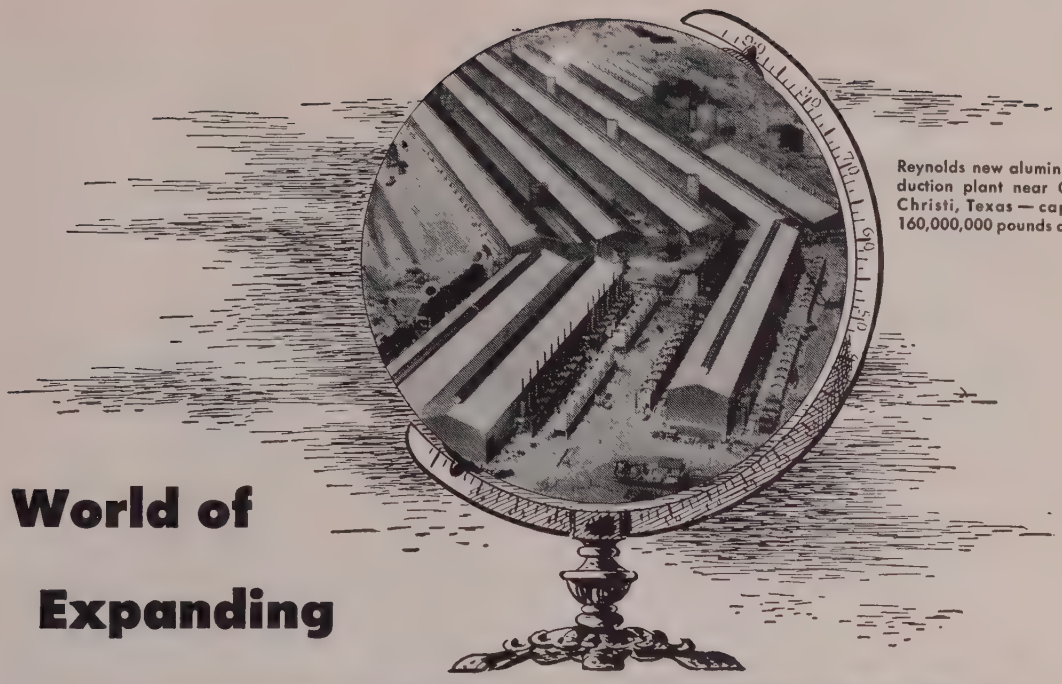


Reynolds new aluminum reduction plant near Corpus Christi, Texas — capacity 160,000,000 pounds a year.

A World of Expanding Opportunity!

In a land noted for rapid expansion of free industrial enterprise, few companies have matched the swift and continuing growth of the Reynolds Metals Company. Now operating 27 plants in 13 states, and still expanding, Reynolds offers the ambitious engineering graduate a world of opportunity.

Reynolds operations include bauxite mining in domestic and foreign locations...chemical and electrolytic processing to produce aluminum pig ...sheet rolling...drawing and extrusion of mill and structural shapes ...foil rolling and printing...powder and paste production...finished parts and products fabrication. In these and in the allied sales and marketing operations promising careers exist for graduates in virtually any phase of engineering.

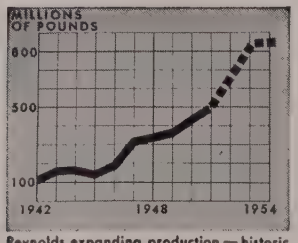
On-the-job training is the Reynolds policy—after preliminary orientation which may include basic experience in production plants for sales personnel, and sales office work for technical trainees. Liberal insurance, hospitalization and retirement programs are maintained.

For important background information on "your future in Aluminum," *mail the coupon.* If you are definitely interested now, write direct to General Employment Manager, Reynolds Metals Company, 3rd and Grace Streets, Richmond 19, Va.

Tapping one of huge battery of electrolytic cells

Sheet rolling—reverse hot mill in operation

REYNOLDS ALUMINUM



Reynolds expanding production — historic chapter in 33 years of continuing growth.

Reynolds Metals Company, Employment Dept.
Richmond 19, Virginia

Please send me, **FREE,** your 96-page booklet, "The ABC's of Aluminum"; also the 44-page book, "Reynolds Aluminum . . . and the Company that makes it."

Name_____

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ELECTRICAL ENGINEER

or

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with an interest in

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Hughes Research and Development Laboratories, one of the nation's leading electronics organizations, are now creating a number of new openings in an important phase of their operation.

Here is what one of these positions offers you:

THE COMPANY

Hughes Research and Development Laboratories, located in Southern California, are presently engaged in the development and production of advanced radar systems, electronic computers and guided missiles.

THE NEW OPENINGS

The positions are for men who will serve as technical advisors to government agencies and companies purchasing Hughes equipment—also as technical consultants with engineers of other companies working on associated equipment. Your specific job would be essentially to help insure successful operation of Hughes equipment in the field.

THE TRAINING

On joining our organization, you will work in the Laboratories for several months to become thoroughly familiar with the equipment which you will later help users to understand and properly employ. If you have already had radar or electronics experience, you will find this knowledge helpful in your new work with us.

WHERE YOU WORK

After your period of training—at full pay—you may (1) remain with the Laboratories in Southern California in an instructive or administrative capacity, (2) become the Hughes representative at a company where our equipment is being installed, or (3) be the Hughes representative at a military base in this country—or overseas (single men only). Compensation is made for traveling and moving household effects, and married men keep their families with them at all times.

YOUR FUTURE

In one of these positions you will gain all-around experience that will increase your value to our organization as it further expands in the field of electronics. The next few years are certain to see large-scale commercial employment of electronic systems. Your training in and familiarity with the most advanced electronic techniques now will qualify you for even more important future positions.

How to apply:

HUGHES

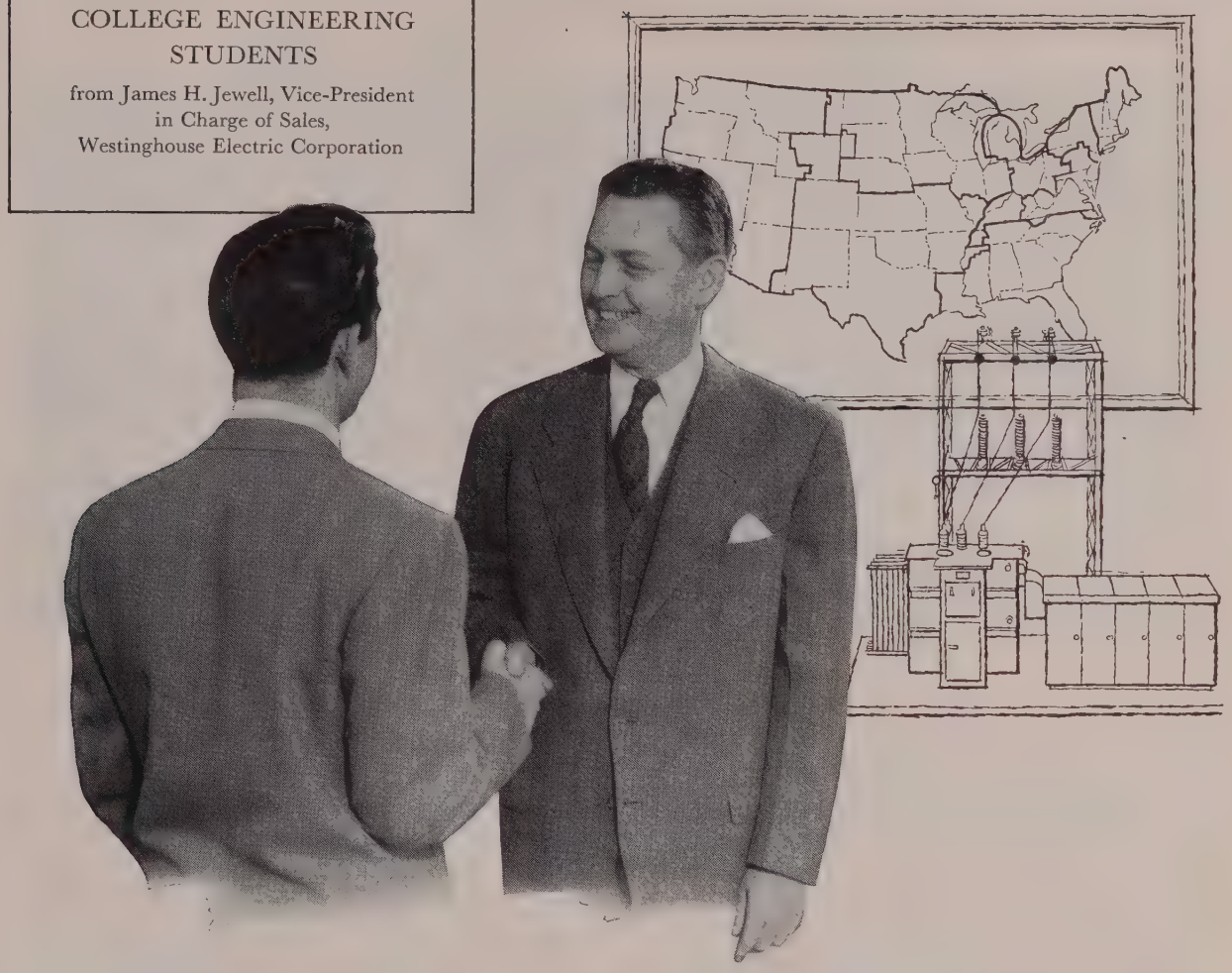
RESEARCH AND DEVELOPMENT LABORATORIES

Scientific and Engineering Staff
Culver City, Los Angeles County, California

See your Placement Office for appointment with members of our Engineering Staff who will visit your campus. Or address your resumé to the Laboratories.

A MESSAGE TO COLLEGE ENGINEERING STUDENTS

from James H. Jewell, Vice-President in Charge of Sales, Westinghouse Electric Corporation



To the young engineer with an eye on sales

Let's agree that engineering is not always to be bounded by the quiet of the research laboratory or the roar of production machinery. Some of us like to meet people, to talk with them, to sell them on our ideas. That's why many young college men, like you, are choosing careers in sales engineering.

The sales engineer is a key man at Westinghouse—an important man in our future. Our products are essential to the defense and development of our country, and applying them to the needs of industry and the military requires men who are technically trained.

Westinghouse is a diversified company. Our products cover a wide range, including equipment for generation and utilization of electrical energy, aviation gas turbines, plastics and atomic power. Westinghouse is a growing company. Our expansion program has greatly increased our productive capacity to meet the growing needs of our nation. And here at Westinghouse, you are given every opportunity for personal development. Well-planned orientation and training, and programs for continued education and management development are integral parts of the Westinghouse plan. Yes, if your eye is on a sales career, you'll find the kind of opportunity you want at Westinghouse.

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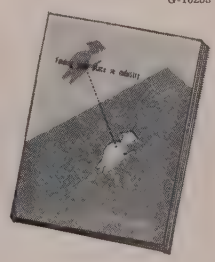


YOU CAN BE SURE...IF IT'S

Westinghouse

Starting Point for a Great Career!

WITHIN a few weeks Pontiac Motor Division will be welcoming engineering graduates from all parts of the country—young men who have chosen Pontiac as the starting point for an engineering career.

Most of them will start out in designing; for this has been shown to be one of the most practical ways to engineering success. In fact, a recent survey found that a majority of the top jobs in the automotive industry are now held by men with broad engineering training—by men whose basic training was in designing.

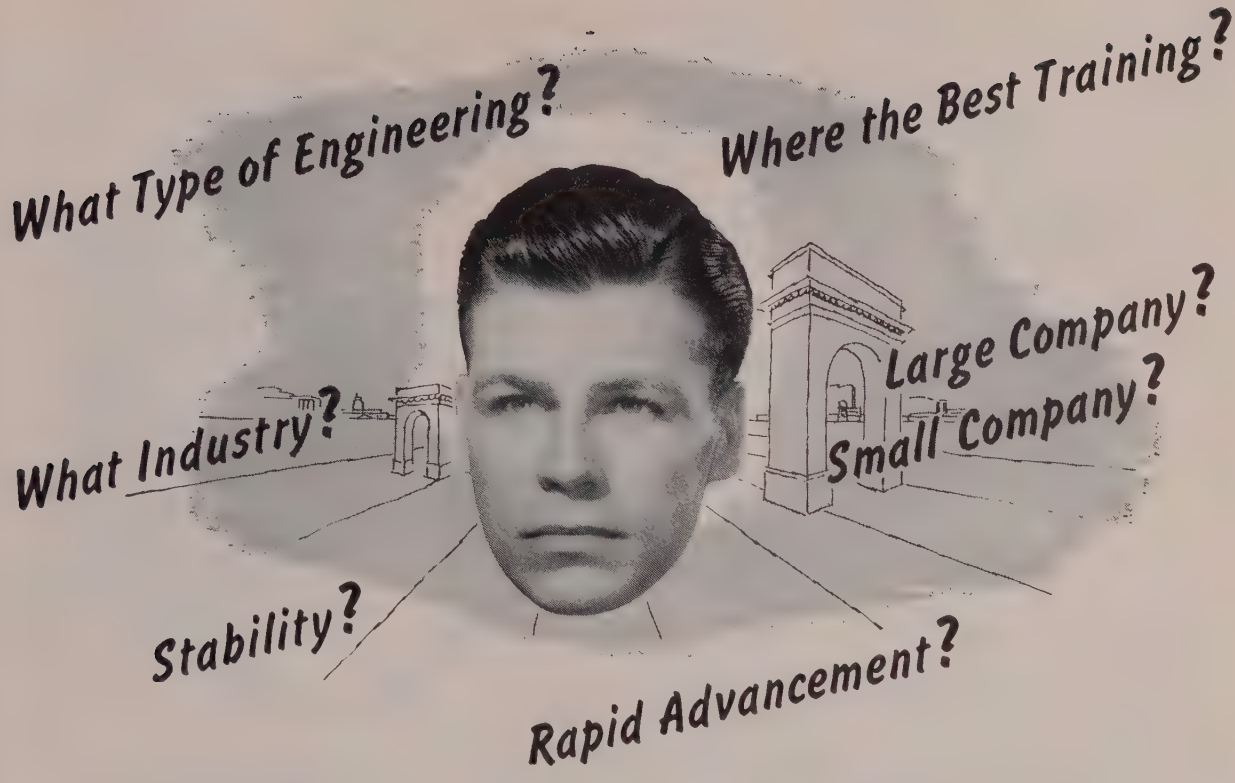
But in addition to a splendid opportunity, Pontiac will also offer these young men the most efficient facilities in its new air-conditioned, well-lighted, 200,000 square foot engineering laboratories—among the industry's most modern, with every conceivable facility for designing better and better Pontiacs.

To those engineering graduates who will soon join Pontiac—and to all others who are about to start on a career—we wish you success.

PONTIAC

MOTOR DIVISION • PONTIAC, MICHIGAN

GENERAL MOTORS CORPORATION



As you look toward your future employment, you'll have many questions to consider. We believe we can give you some interesting facts which may help you find the answers.

We'd like to tell you about the electrical industry and where it's going. More specifically, we'd like to tell you about Square D and what we have to offer.

GEORGIA TECH, ILLINOIS, IOWA STATE, MICHIGAN, OHIO STATE, PENN STATE, PURDUE, TEXAS A & M, WISCONSIN—for years, Square D has been looking to these great schools for its engineering talent. Electrical, mechanical, industrial and general engineers—all make up the Square D team. It's a strong team—one we think you'd like to be a part of.

Mail the Coupon...

...for your copy of a 16-page "Get-Acquainted" brochure which tells a lot about Square D, its products, services, markets and opportunities.

Square D Company, Dept. SA
6060 Rivard Street, Detroit 11, Michigan

I'd like a copy of
Square D's "Get-Acquainted" brochure.

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City_____ Zone_____ State_____

SQUARE D COMPANY

THE OPPORTUNITY IS HERE!

YOUR ADVANCEMENT IS UP TO YOU!

SUNDSTRAND

IT'S THE FIRST JOB THAT COUNTS. GET YOURSELF OFF TO A GOOD START BY PLACING YOURSELF WITH A COMPANY THAT IS "GOING PLACES". SUNDSTRAND IS LARGE ENOUGH TO OFFER UNLIMITED OPPORTUNITY AND SMALL ENOUGH TO RECOGNIZE YOUR INDIVIDUALITY. IF YOU ARE LOOKING FOR STIMULATING AND CHALLENGING ENGINEERING ASSIGNMENTS IN A NEWLY DEVELOPED INDUSTRY, GROWING FROM DAY TO DAY, SUNDSTRAND IS THE NAME TO REMEMBER.

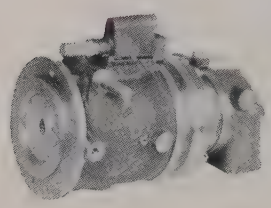
Domestic Oil Burner Pumps

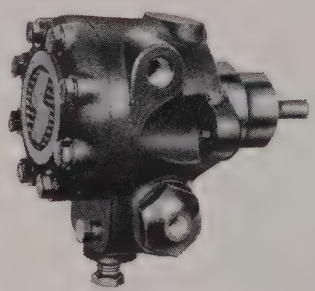
Industrial Hydraulic Motors Valves, and Pumps

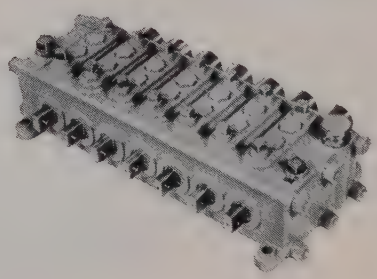
Aircraft Hydraulic Transmissions and Pumps

Aircraft Fuel, Lube, and Charge Pumps

Electrical and Hydraulic Servo Mechanisms



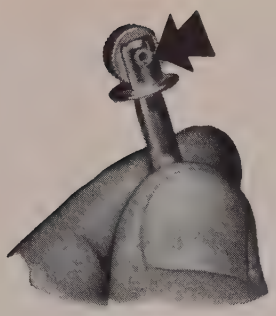




For further information about your engineering career and future, write at once to *H. H. Ekstrom,*

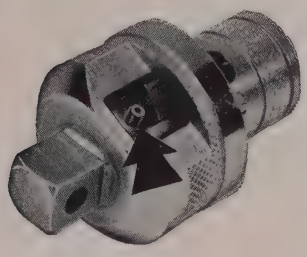
SUNDSTRAND MACHINE TOOL COMPANY

2531 Eleventh Street, Rockford, Illinois

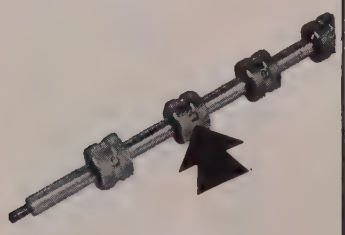


Replacing a rivet

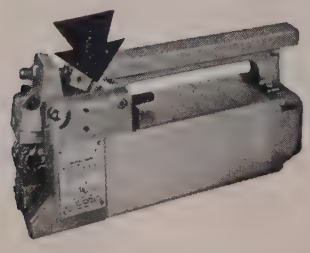
. . . a hinge pin



. . . a stop pin

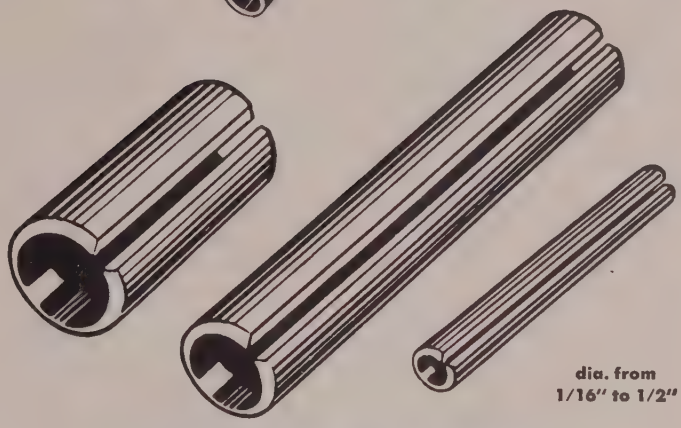


. . . a set screw



. . . a bolt and nut

ROLLPIN



dia. from 1/16" to 1/2"

. . . a modern fastener that saves time and money on thousands of applications

Rollpin is a hollow, split, cylindrically formed pin with chamfered ends. It is simply driven into holes drilled to normal production tolerances. Because Rollpin is slightly larger than standard sized holes, it compresses as inserted. It is self-locking—and vibration-proof—because of the constant pressure it exerts against hole walls. Its shear strength exceeds that of a cold rolled pin of the same diameter. Rollpin is readily removed with a drift or pin punch—and can be reused.

Because of its versatility—and the production economies it makes possible—Rollpin is finding wide usage in almost every phase of manufacturing activity. Write for design information on the Rollpin. It will enable you to cut costs for many applications where use of rivets, set screws, dowels, and straight, serrated or cotter type pins create installation or performance problems.

ELASTIC STOP NUT CORPORATION OF AMERICA

2330 Vauxhall Road, Union, New Jersey

Elastic Stop Nuts with the famous red collar are another ESNA product

SYNTHANE—out of sight, but in the picture

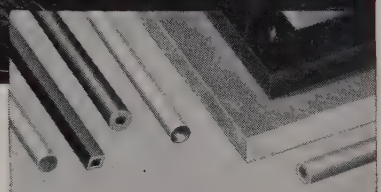
Whenever you turn on television you are using a little-seen, but essential, material called Synthane.

Synthane is a laminated plastic of multiple virtues, which recommend it for many jobs in television.

Synthane is an excellent insulator, laminable with metal, hence, a good base for space-reducing "printed" circuits. Synthane is notable for low power factor, low moisture absorption, and ease of fabrication, three properties desirable for radio and television insulation. Synthane plays a supporting part in many behind-the-screen and behind-the-camera applications.

Synthane is also light in weight, strong, vibration absorbing, chemically resistant, high in dielectric strength, dimensionally stable, heat resistant to about 300°F.

There may be a place for Synthane in your product. To find out more about the possibilities of Synthane for your purpose, write for the complete Synthane Catalog. Synthane Corporation, 42 River Road, Oaks, Pennsylvania.



Synthane laminated plastics are produced under heat and pressure from laminations of resin-impregnated materials such as paper, fabric, glass cloth, asbestos, etc. Synthane plastics are available in sheets, rods, tubes, and fabricated or molded parts. Each of the many Synthane grades has a combination of useful properties.

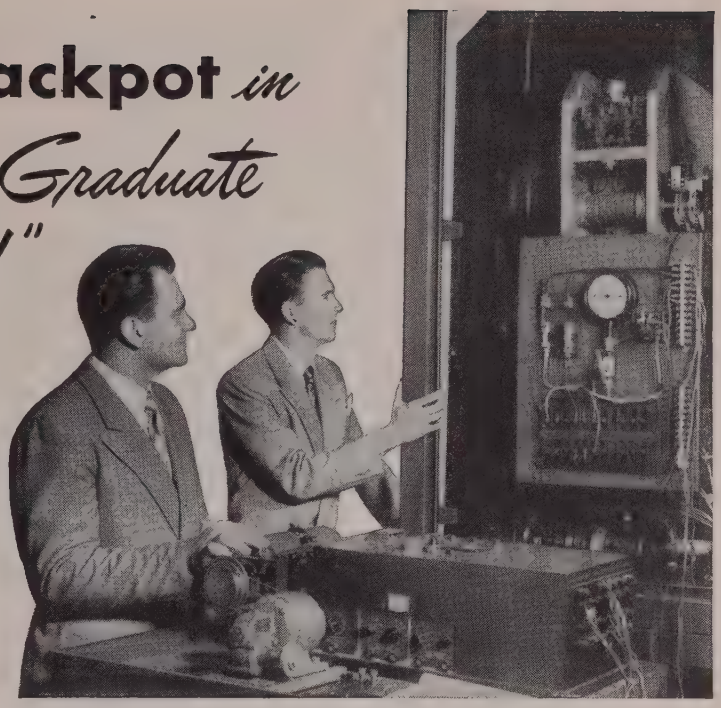
Synthane in Television

A—Television camera parts
B—Television receiver printed circuits—metal foil on Synthane sheets
C—Channel selector switch insulation

Synthane—one of industry's unseen essentials

SYNTHANE
S
LAMINATED PLASTICS

"We Hit the Jackpot *in* Allis-Chalmers Graduate Training Course!"



say N. W. MORELLI

Oregon State College, B.S.,M.E.—1950

and

E. R. PERRY

Texas A. & M., B.S.,E.E.—1950

WHILE taking the course, two engineers developed a revolutionary new circuit breaker mechanism.

"Our experience shows what *can* happen if you work with people open to suggestion. We found men of this kind at Allis-Chalmers, and it has given us a special pleasure in our job.

"We started out like most other graduates with a hazy idea of what we wanted to do. After working in several departments, we requested that part of our training be at the Boston Works of Allis-Chalmers, where circuit breakers are made."

New Design Principle

"Circuit breakers soon became an obsession with us, and we got the idea of designing a hydraulic operator and triggering mechanism for these breakers. Most operators for big breakers are pneumatic.

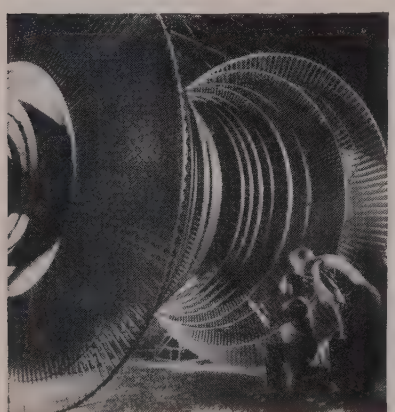
"Unsuccessful attempts had been made in the past by all circuit breaker manufacturers to build hydraulic operators. The important thing is that no one at Allis-Chalmers said, 'Don't try it—it won't work.' "

Start New Era

"To make a long story short, our study of the problem led us to the hydraulic accumulator and high speed valves being used by the aircraft industry. These had not been available when earlier attempts were made to build a hydraulic operator. With these highly developed devices to work with, we were able to build an operator that combined the best features of pneumatic and hydraulic operation. We call it the *Pneu-draulic* operator. Engineers are saying it starts a new era in circuit breaker actuation.

"This fact is important to us, but it is even more important to know that Allis-Chalmers Graduate Training Course is full of opportunity . . . and as we found out, there's opportunity right from the start."

Pneu-draulic is an Allis-Chalmers Trademark.



Low-pressure spindle for a 120,000 kw steam turbine generator. Said to be one of the largest ever built in the United States, this spindle is nearing completion in the Allis-Chalmers West Allis shops.

Facts You Should Know About the Allis-Chalmers Graduate Training Course

1. It's well established, having been started in 1904. A large percentage of the management group are graduates of the course.

2. The course offers a maximum of 24 months' training.

3. The graduate engineer may choose the kind of work he wants to do: design, engineering, research, production, sales, erection, service, etc.

4. He may choose the kind of power, processing, or specialized equipment with which he will work, such as: steam or hydraulic turbo-generators, circuit breakers, unit substations, transformers, motors, control, pumps, kilns, coolers, rod and ball mills, crushers, vibrating screens, rectifiers, induction and dielectric heaters, grain mills, sifters, etc.

5. He will have individual attention and guidance in working out his training program.

6. The program has as its objective the right job for the right man. As he gets experience in different training locations he can alter his course of training to match changing interests.

7. For information watch for the Allis-Chalmers representative visiting your campus, or call an Allis-Chalmers district office, or write Graduate Training Section, Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS AC ALLIS-CHALMERS

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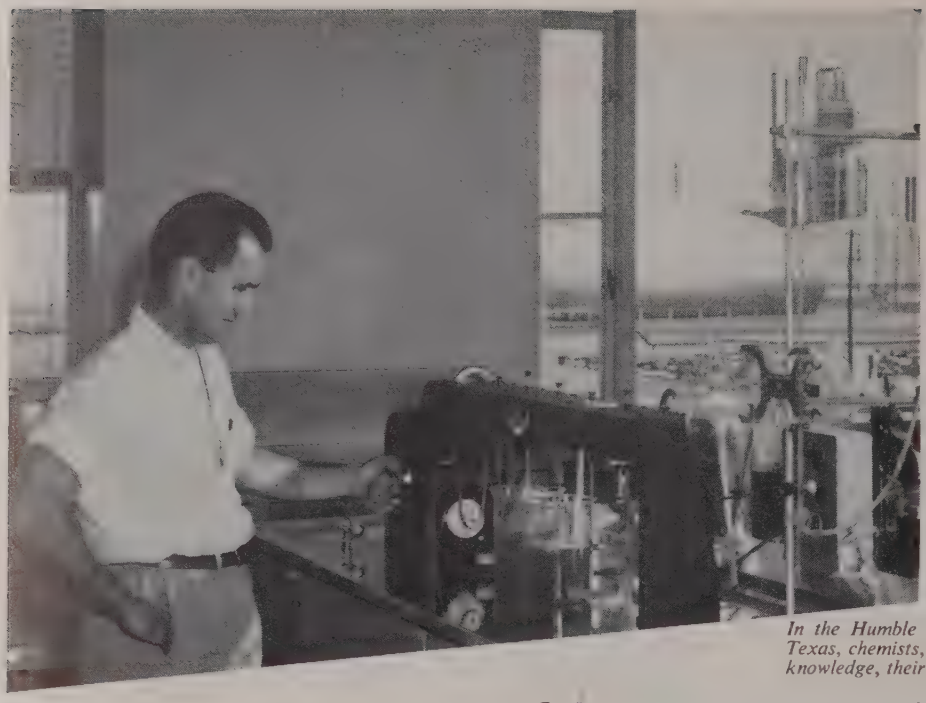

In the Humble Research Laboratory at Baytown, Texas, chemists, physicists and engineers pool their knowledge, their training and their experience.

A year from now, the suit you wear may get its start at BAYTOWN, TEXAS

At its Baytown, Texas, refinery the Humble Company has started the construction of facilities to make paraxylene from petroleum hydrocarbons. This paraxylene is the raw material for *dacron*, one of the miracle fibers of modern times.

But paraxylene is only one of a hundred different petroleum products made at Baytown. Gasoline, of course, but *far* better gasoline than that of 10 years ago, *better* gasoline than last year's even. Other fuels—for airplanes, for locomotives, for ships. Lubricants. Solvents. Butadiene. Waxes, Toluene. Alcohol . . . It's a list too long for cataloging here.

. . . The starting point for most improved and new petroleum products made at Baytown is the Research Laboratory. There chemists, physicists and engineers pool their knowledge, their training and their experience to devise new combinations of hydrocarbons, to improve refining methods, to extend the usefulness of each barrel of hard-to-find oil.

The ultimate consumer is the chief beneficiary. Almost annually he gets better petroleum products at prices that have remained, for these times, relatively stable, so that Baytown and other great oil refineries are Exhibit A in the case for individual enterprise in the American democratic system . . . It makes working at Baytown a *satisfying* job.

HUMBLE OIL & REFINING CO.

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HUMBLE

The Humble Company carries on Exploration Work in nine states—Alabama, Arizona, California, Florida, Georgia, Louisiana, Mississippi, New Mexico, and Texas . . . Wells Drilled by Humble total 1,200—1,500 annually . . . Crude Oil Production averages more than 380,000 barrels daily . . . Oil and Gas Production Taxes total about $18 million annually . . . Refining Operations of 270,000 barrels of oil daily are centered at Baytown, Texas . . . Retail Sales Activities are confined to Texas and New Mexico. Humble is the leading Texas marketer . . . Humble Pipe Line Company operates 5,895 miles of crude oil and product trunk lines in Texas and New Mexico and transports an average of 722,000 barrels per day of crude oil and finished products.

William R. Parlett, Cornell '48, Sets Sights on Executive Sales Job

BILL PARLETT has learned that helpful engineering suggestions promote good customer relations.

"Within the next ten years", says William R. Parlett, young Worthington Sales Engineer, "many of the officers of the corporation district office sales managers and top salesmen will be retired.

"Appreciating the fact that someone must fill these jobs, our management is striving to develop capable leadership among the younger men of the corporation.

"As a prospective Worthington Sales Engineer, I received several months of classroom instruction by works managers, top sales personnel and application engineers at all of the Worthington plants. The background I obtained was a sound basis for further development and learning gained in one of the product sales divisions and then in a district sales office. After obtaining sufficient product knowledge and sales training, I was ready to sell directly to industry. As more important sales assignments are available, I feel I will progress in proportion to my own development and sales performance.

"As a Worthington salesman I contact a class of trade with which it is a pleasure to do business. The company's reputation is a key to a welcome reception by my customers.

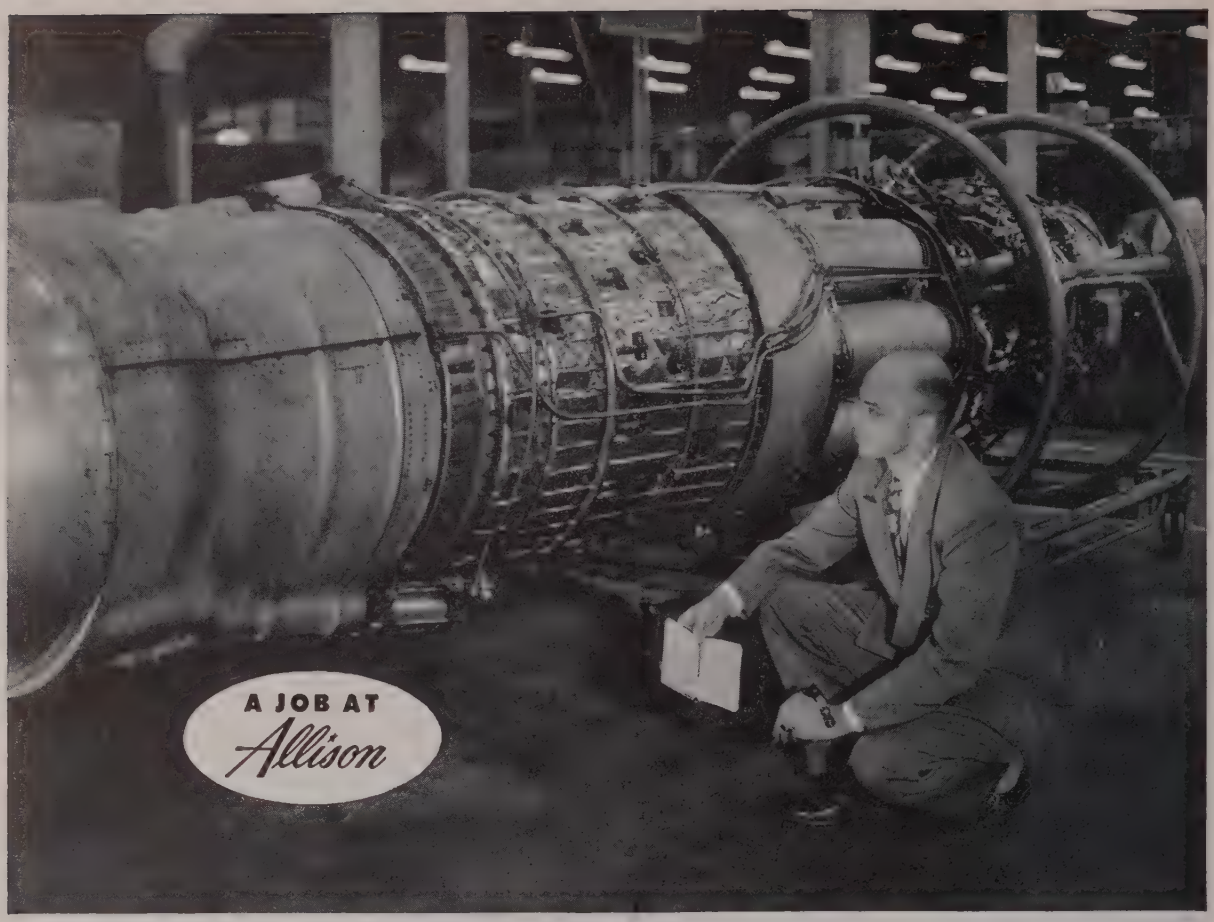
"I have found that with Worthington you have job satisfaction, adequate compensation, and unlimited opportunity."

When you're thinking of a good job, think *high*—think *Worthington.* 3.6

FOR ADDITIONAL INFORMATION, see your College Placement Bureau or write to the Personnel and Training Department, Worthington Corporation, Harrison, N. J.

WORTHINGTON

The Sign of Value Around the World



● Earle R. Wall, Jr. was graduated from Virginia Polytechnic Institute in 1941 with a B. S. degree in Mechanical Engineering and after a five year tour of duty with the Army came to Allison to do pioneering work on turbo-jet engines.

Earle today has an important job as an engineer in the turbo-jet design group and he is working on afterburners for some of America's newest jet engines. Allison Division was the first aircraft engine manufacturer to produce turbo-jet afterburners. The afterburner is a thrust augmentation unit for jet engines to give the engine more thrust in take-off, climb and combat emergencies. An additional cone is added after the turbine where more fuel is injected into the exhaust gases of the engine and ignited to give a larger amount of thrust.

Earle's job includes the thermodynamic and mechanical design of afterburners which must diffuse exhaust gases from the turbine at temperatures over 1650 degrees Fahrenheit, with a minimum loss of energy, and consume additional fuel for thrust augmentation. After the correct design has been calculated and drawn, prototypes of the afterburner are tested by the Test Control group and Earle then analyzes results. One of the many problems is the endurance life of the exhaust unit. He must make a choice of present metals or search for new metals to withstand the high temperatures and forces of the gases which pass through.

Earle and many other Allison engineers have interesting, important jobs in the science of jet engines. They are making a direct contribution to national defense and adding to their own knowledge of a subject which offers lifetime careers for engineers.

Allison is looking for young men with degrees in **MECHANICAL ENGINEERING, ELECTRICAL ENGINEERING, AERONAUTICAL ENGINEERING** ***and*** **INDUSTRIAL ENGINEERING.** ***There are also a number of openings for majors in Metallurgy, Electronics, Mathematics and Physics.*** Write now for further information: R. G. Greenwood, Engineering College Contact, Allison Division, General Motors Corporation, Indianapolis 6, Indiana.

Allison

DIVISION GENERAL MOTORS CORPORATION • Indianapolis, Ind.

Design, development and production—high power TURBINE ENGINES for modern aircraft . . . heavy duty TRANSMISSIONS for Ordnance and Commercial vehicles . . . DIESEL LOCOMOTIVE PARTS . . . PRECISION BEARINGS for aircraft, Diesel locomotives and special application.

Do you want to get ahead in engineering?

Then—after you graduate—join a company that's expanding in fields where big engineering futures lie.

At Boeing you'll find plenty of room to get ahead in such projects-with-a-future as a major guided missile program . . . research in supersonic flight and nuclear-powered aircraft . . . America's first-announced jet transport . . . and the revolutionary B-47 and B-52 jet bombers.

You'll find Boeing a stable 36-year-old company, that has grown practically continuously. For example, Boeing now employs 6000 engineers in contrast to 3500 at the peak of World War II. And although Boeing is a large concern, it is so organized that each engineer is an individual who stands out—and progresses—in proportion to his ability.

Boeing is constantly alert to new techniques and materials — and approaches them without limitations. Extensive subcontracting and major procurement programs — directed and controlled by engineers—give you a varied experience and broad contacts with a cross section of American industry. No industry, in fact, matches aviation in offering such a wide range of experience, or breadth of application — from pure research to production design, all going on at once.

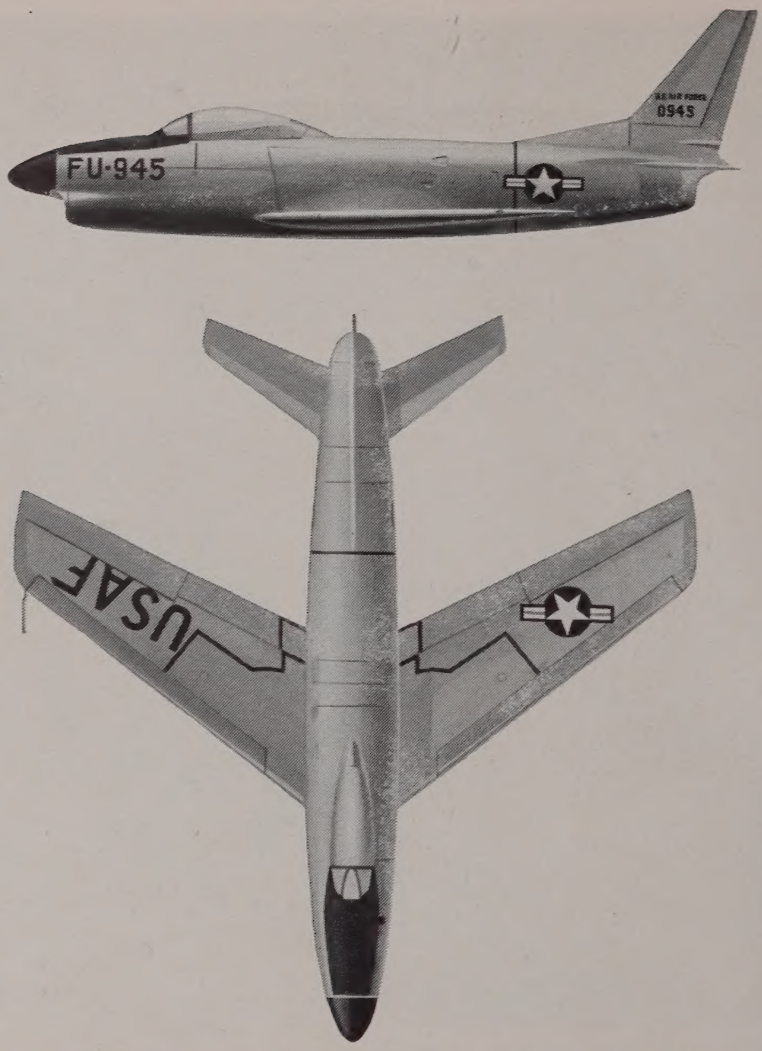
Boeing engineering activity is concentrated at Seattle in the Pacific Northwest, and Wichita in the Midwest. These communities offer fishing, hunting, golf, boating and other recreational facilities. Both are fresh, modern cities with fine residential and shopping districts, and schools of higher learning where you can study for advanced degrees.

There are openings in ALL branches of engineering (mechanical, civil, electrical, aeronautical, and related fields), for **DESIGN, DEVELOPMENT, PRODUCTION, RESEARCH and TOOLING.** Also for servomechanism and electronics designers and analysts, and physicists and mathematicians with advanced degrees.

For further information, consult your Placement Office, or write:

JOHN C. SANDERS, Staff Engineer—Personnel
Boeing Airplane Company, Seattle 14, Washington

BOEING



YOUR IDEAS

Will Keep Planes Like This On The American Team

What makes great planes like North American Aviation's F-86D and sister *Sabre* jets? The answer is new ideas . . . young ideas. And just as the ideas of young engineers of a decade past helped perfect the plane you see above, so will the ideas of today's engineering students—your ideas—perfect tomorrow's F-???. That's why North American Aviation always has challenging career opportunities for bright, young graduate engineers.

Today, North American is developing projects of a new era—aircraft, guided missles, rocket engines, rockets, electronics, atomic energy. If you'd enjoy the challenge of pioneering in these advanced fields, consider looking to the future with North American when you complete your engineering training. In the meantime, feel free to write for information concerning a career in the aircraft industry.

Your student placement office will be glad to supply you with more detailed information. Or if you prefer, write direct, including your name, address, placement preference and personal data. Please address your reply to:

D. R. Zook, Employment Director, 5701 W. Imperial Highway, Los Angeles

NORTH AMERICAN AVIATION, INC.

Los Angeles, California • Columbus, Ohio

NORTH AMERICAN HAS BUILT MORE AIRPLANES THAN ANY OTHER COMPANY IN THE WORLD

PHOTOGRAPHY AT WORK No. 2 in a series:

Knitting mill solves help shortage, attracts and keeps full staff

Hand Knit Hosiery Company of Sheboygan, Wisc., knitters of Wigwam Socks, found many potential employees resisted jobs simply because they didn't know the sort of opportunities offered.

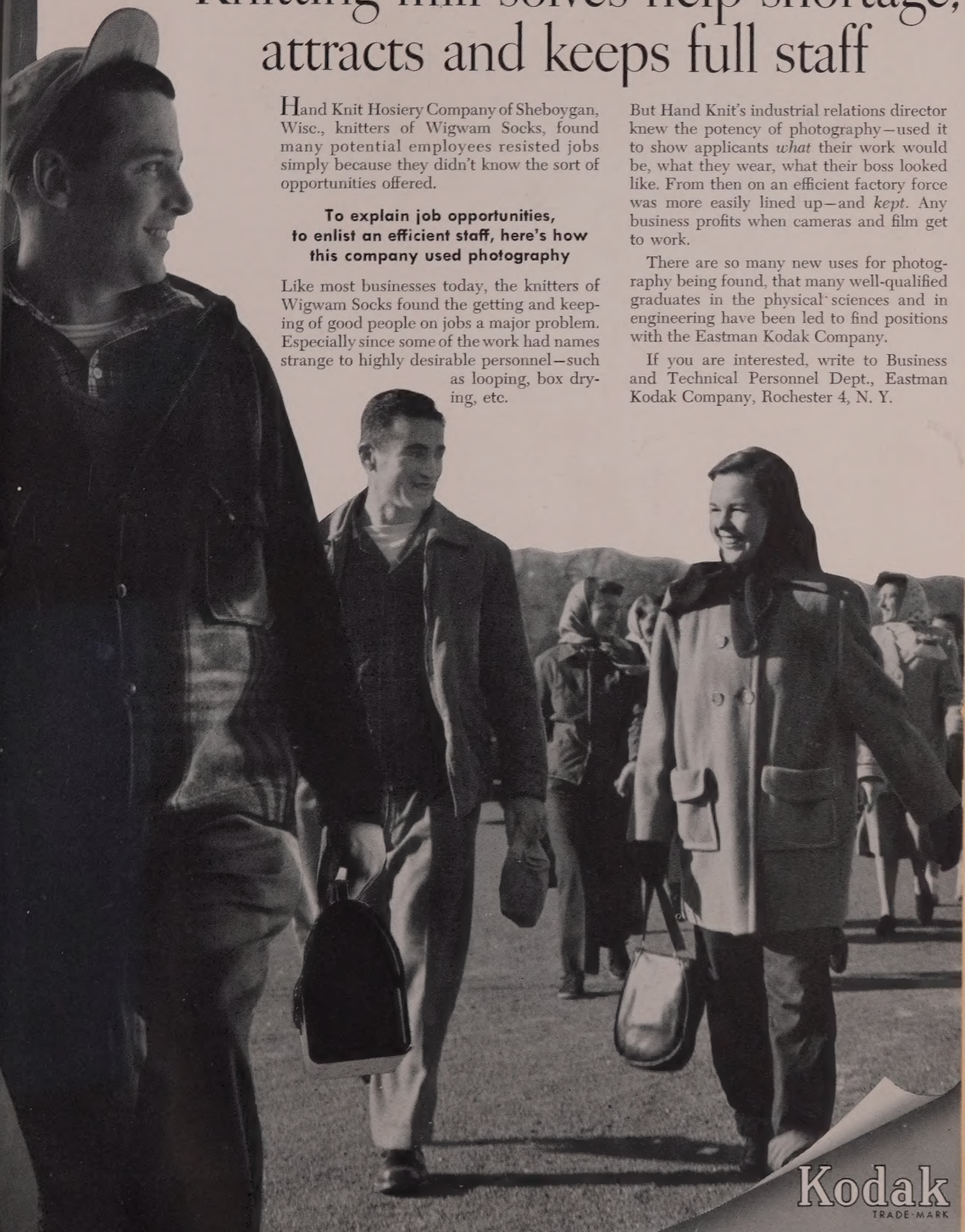
To explain job opportunities, to enlist an efficient staff, here's how this company used photography

Like most businesses today, the knitters of Wigwam Socks found the getting and keeping of good people on jobs a major problem. Especially since some of the work had names strange to highly desirable personnel—such as looping, box drying, etc.

But Hand Knit's industrial relations director knew the potency of photography—used it to show applicants *what* their work would be, what they wear, what their boss looked like. From then on an efficient factory force was more easily lined up—and *kept*. Any business profits when cameras and film get to work.

There are so many new uses for photography being found, that many well-qualified graduates in the physical sciences and in engineering have been led to find positions with the Eastman Kodak Company.

If you are interested, write to Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.



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6 WAYS TO BEGIN A SUCCESSFUL CAREER

TEST ENGINEERING PROGRAM—offers engineering graduates opportunities for careers not only in engineering but in all phases of the Company's business. Includes rotating assignments plus opportunities for classroom study.

BUSINESS TRAINING PROGRAM—open to business administration, liberal arts, and other graduates . . . for careers in accounting, finance, administration, and other fields. Includes on-the-job training plus classroom study.

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MANUFACTURING TRAINING PROGRAM—for developing leaders in the field of manufacturing. Open to graduates with a technical education or a general education with technical emphasis.

ADVERTISING TRAINING COURSE—offers graduates career opportunities in all phases of advertising, sales promotion, and public relations work. Includes on-the-job training and a complete classwork program.

PHYSICS PROGRAM—offers physicists rotating assignments in applied research in many fields of physics plus ample opportunity for organized classroom study. Program graduates have gone into such fields as research, development, manufacturing, design, marketing.

FEW companies can offer as broad a range of career opportunities as General Electric. Whether a young man is interested in science or engineering, physics or chemistry, electronics or atomic energy, plastics or air conditioning, accounting or sales, employee relations or advertising, drafting or jet engines . . . he can plan for himself a G-E career.

The training programs summarized here are only a few of the "open doorways" that lead to successful careers in a company where big and important jobs are being done, and where young people of vision and courage are needed to help do them.

If you are interested in building a G-E career after graduation, talk with your placement officer and the G-E representative when he visits your campus. Meanwhile, for further information write to College Editor, Dept., 2-123, General Electric Co., Schenectady 5, New York.

You can put your confidence in—

GENERAL ELECTRIC